

# Needle Roller Bearings



# NSK NEEDLE BEARING

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## **Introduction**

### Newly Revised & Updated NSK Needle Roller Bearing Catalog

Welcome to the latest edition of the NSK Needle Roller Bearing catalog (Catalog No. E1419c). Our new catalog has been revised and updated to better meet the needs of our customers.

NSK needle roller bearings enjoy a favorable reputation and are well accepted in the industrial machinery marketplace. NSK will continue to meet the future needs of industry by further developing automation-related products that are more compact, lightweight, consume less energy, and offer extended maintenance-free performance.

This newly revised NSK needle roller bearing catalog has been enhanced with a wealth of information that spans many years of amassing empirical data from many sources around the world.

We are convinced that this catalog will prove to be more helpful to you in selecting the optimum bearing for your application. Choose the optimal NSK needle roller bearing for your application from among the types and features offered in this catalog. Please feel free to contact us with any feedback, comments or suggestions you may have.

MOTION & CONTROL

**NSK**

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# Needle Roller Bearings

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CAT.No.E1419c

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## 1. Bearing Types and Features

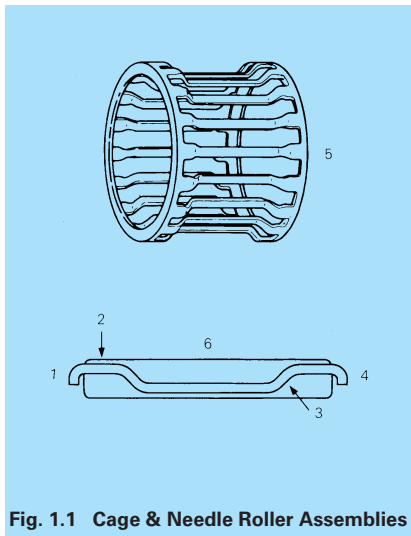
Needle roller bearings are a type of roller bearings and are classified as either radial or thrust depending on the direction of the load they support. Needle roller bearings include bearings whose rollers slightly exceed the size range of needle rollers as stipulated by ISO.

Needle roller bearings include drawn cup and solid radial bearings, as well as application-specific cam followers, roller followers. Thrust bearings include thrust needle bearings. Although not classified as a rolling bearing, there is also a spherical sliding bearing that supports radial and axial loads.

This catalog presents the various types of needle bearings and their features. For easy reference, the numbers in each section from 1.1 through 1.0 correspond to the numbers in Figs. 1.1 through 1.9.

### 1.1 Cage & Needle Roller Assemblies

1. The cage has a unique structure that facilitates handling by holding the rollers securely in place.



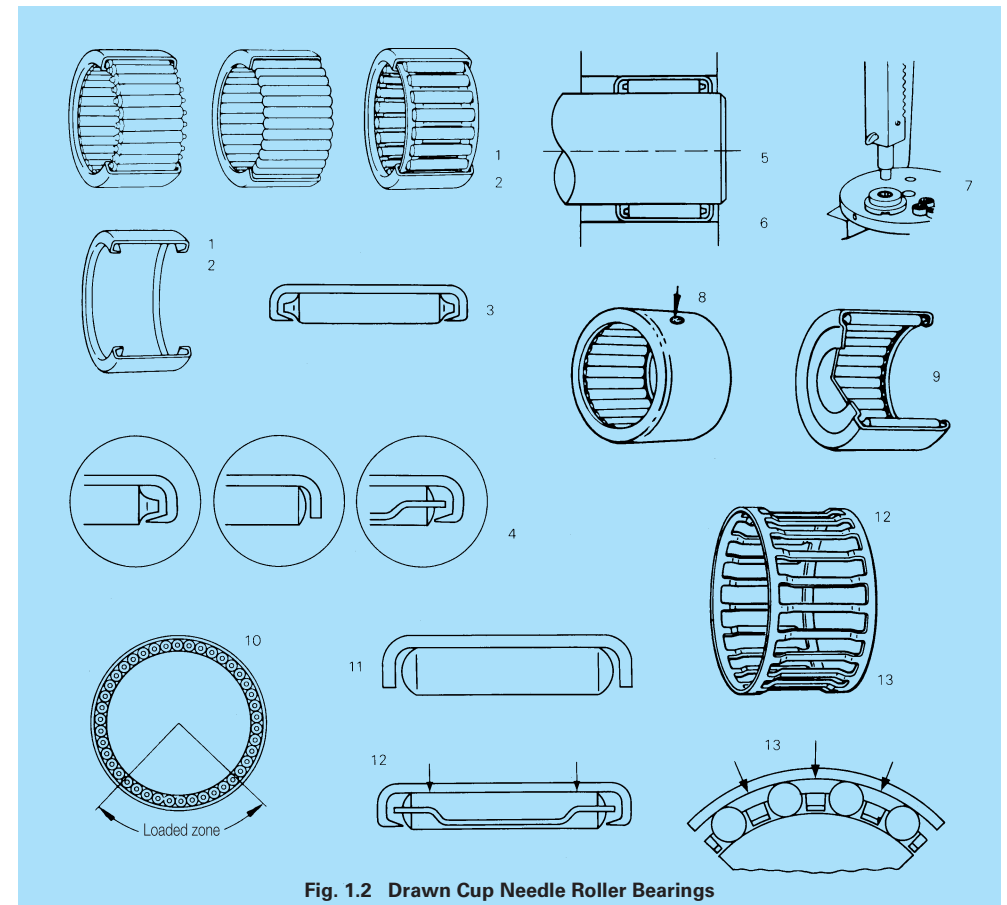
2. The outside surface of the cage serves as a guide face and helps create favorable lubricating conditions.
3. The cage guides the rollers accurately to ensure that stable roller movement is maintained.
4. The single-piece cage has high strength and rigidity and facilitates the free circulation of lubricant.
5. High load capacity is possible due to the presence of many rollers of relatively long length.
6. To prevent stress concentrations on both ends of the rollers (edge loads), appropriate crowning is applied.

### 1.2 Drawn Cup Needle Roller Bearings

1. NSK drawn cup needle roller bearings are available in two types: caged and full complement. Drawn cup outer rings are made of carefully selected alloy steel sheet. They are surface-hardened after precise pressing, giving them a unique structure.
2. The outer ring is precisely pressed and is in tight line contact with the rollers. Optimum heat treatment gives the raceway surface uniform strength and the ability to carry heavy loads.
3. The low height of the bearings saves space so machines can be made more compact and lightweight.
4. The bent part of the drawn cup outer ring securely holds the rollers and/or cage and acts as a labyrinth seal that prevents both the entry of dust and dirt and lubricant leakage. At the same time, it enhances the strength of the outer ring end faces.
5. When the shaft has adequate hardness and is finished to proper dimensional accuracy, the inner ring can be omitted and space in the radial direction can be saved.
6. As securing in the axial direction is achieved by press fitting, a locating snap ring, collar, housing shoulder or the like is not required. This simplifies the housing structure and facilitates low-cost design.

7. Mounting is made easier because press fitting can be performed with an arbor press or the like.
8. Lubricating the bearing is easy and a lubrication hole can also be provided upon request.
9. If a closed type is used at the shaft end, savings can be made on the housing end cover.
10. The full complement roller bearing carries the load on many rollers and thus maximizes load capacity.

11. Among full complement roller bearings, bearings whose rollers are held in place by grease before assembly have the maximum load capacity because the rollers have the longest possible length.
12. The cage of the needle bearing accurately guides the rollers at the pitch diameter of the rollers. The surface of the cage is hardened to reduce frictional torque and increase rigidity and wear resistance.
13. The unique structure of the cage allows extensive space for storing lubricant, thus enabling smooth lubricant circulation and increasing grease life.



### 1.3 Solid Needle Roller Bearings

1. The bearing ring can sustain high shock loads because it is precisely ground after being heat treated.
2. Providing high load capacity, many rollers are held in the outer ring by strong integrated ribs.
3. The unique single-piece cage is also excellent for high speeds as the cage accurately guides the rollers at the roller pitch diameter at both ends of the rollers.
4. Considerable space is allotted for lubricant and lubricant life is long.
5. The cage is surface treated, increasing wear resistance and rigidity.
6. Appropriate crowning is applied to the rollers to avoid edge load.
7. Outer rings provided with a lubrication groove and lubrication hole facilitate the replenishment of lubricant.
8. As the size variation per unit of roller diameter is small, the distribution of the roller load is favorable and bearing life is long.

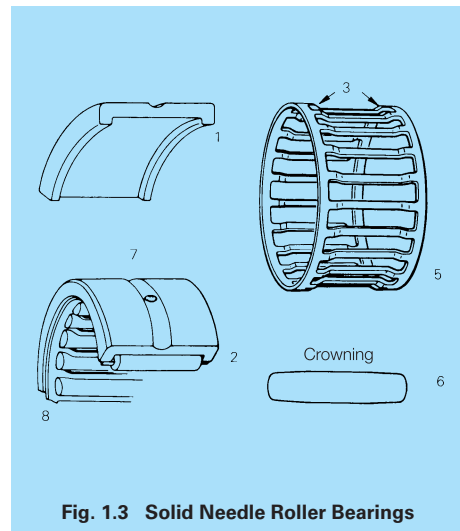


Fig. 1.3 Solid Needle Roller Bearings

### 1.4 Thrust Bearings

#### 1.4.1 Thrust Needle Bearings

1. Making compact design feasible, the height of the cross-section is similar to that of a conventional thrust washer.
2. The cage, which is made of two steel sheets precisely pressed, holds and accurately guides the rollers. The cage is surface hardened to increase wear resistance and rigidity.
3. There are thrust washers of various thicknesses available to meet the requirements of different applications.

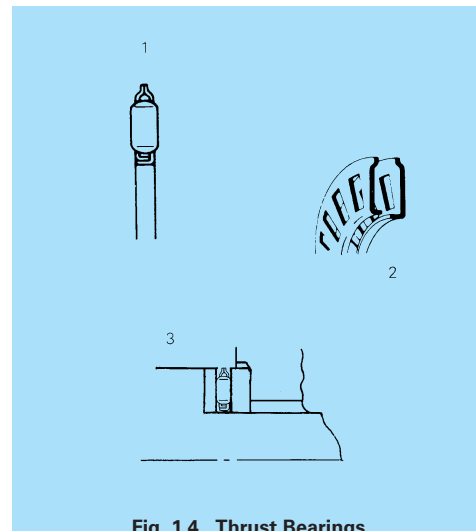


Fig. 1.4 Thrust Bearings

### 1.5 Cam Followers and Roller Followers

1. The thick-walled outer ring made of high-carbon chromium bearing steel, which is finished by grinding after hardening, has high shock resistance and is highly resistant to deformation.
2. The cam follower has lubrication holes in three places. Lubrication can be provided easily from any of these three locations.
3. Crowning is applied to the rollers in order to avoid edge loading.
4. The labyrinth seal structure reduces friction. In addition, a special thrust washer is integrated in order to enhance heat seizure resistance.
5. Increasing shock resistance, the shaft of the cam follower has a hardened raceway surface.
6. The roller follower can carry heavy loads because both ends are supported.

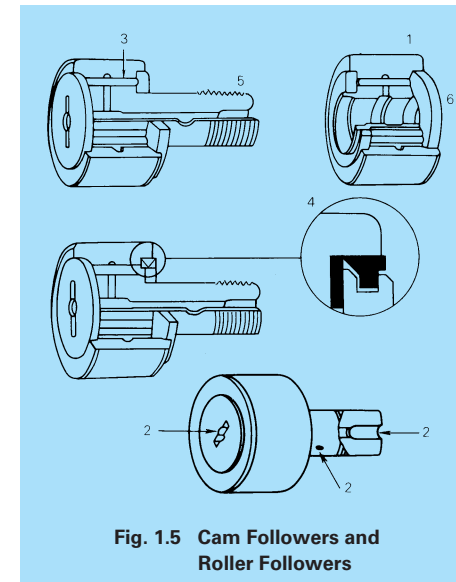


Fig. 1.5 Cam Followers and Roller Followers

### 1.6 Needle Rollers

- There are a variety of end faces available from which an appropriate shape can be selected for specific applications.
1. Rounded rollers are the most widely used.
  2. Flat rollers have a longer effective load-carrying length.
  3. Crank pin rollers are suitable for where the corner of the shaft or housing step is considerably rounded.
  4. Appropriate crowning can be applied for various usage conditions.

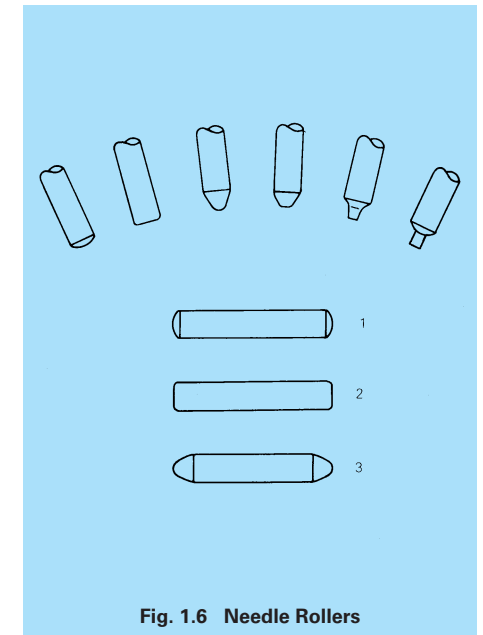
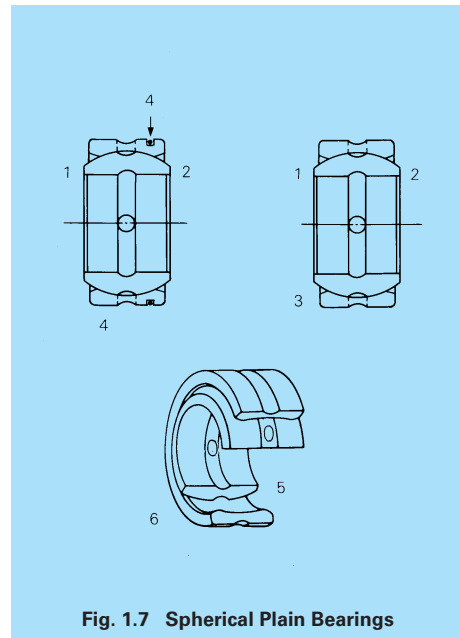


Fig. 1.6 Needle Rollers

### 1.7 Spherical Plain Bearings

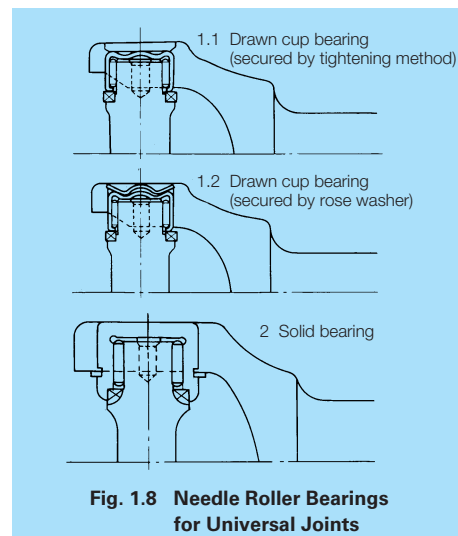
1. Since the structure is composed simply of an inner ring with spherical outside and an outer ring with a spherical bore, this bearing is ideal for applications where the inner and outer rings are misaligned.
2. Carefully selected high-carbon chromium bearing steel is used, and high load capacity is achieved thanks to ideal hardening.
3. Bearings with single-cut outer rings are not separable even without snap rings.
4. Bearings with double-cut outer rings are assembled by a wire snap ring into a single body.
5. The lubrication grooves and lubrication holes provided in the inner and outer rings facilitate re-lubrication.
6. After phosphate coating, a coating of molybdenum disulfide is applied to the whole surface.



### 1.8 Needle Roller Bearings for Universal Joints

Needle roller bearings for universal joints include two types: drawn cup and solid.

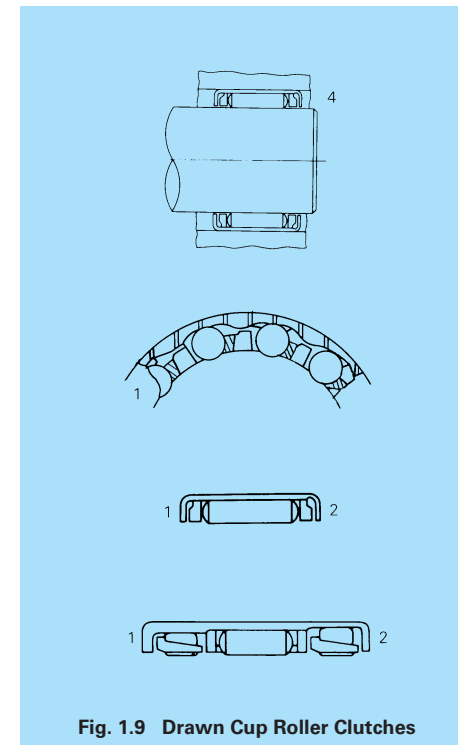
1. While the tightening method is mainly used for securing drawn cup needle bearings in a yoke hole, another method employs a rose washer and bearing assembly is carried out using special equipment. Universal joints made by assembling drawn cup needle bearings have the following characteristics:
  - (a) It is possible to impose a light preload between the bearing inner bottom and cross shaft end.
  - (b) It is possible to have the cross shaft's rotating center aligned with the shaft center.
  - (c) Universal joints made in this way are economical and contribute to making products more compact and lightweight.
2. As solid needle bearings can sustain heavier loads than drawn cup needle bearings, universal joints with solid needle bearings are suitable for medium and heavy-duty motor vehicles.



### 1.9 Drawn Cup Roller Clutches

There are three types with a clutch only: FC, FCL and RC; and three types with a clutch and bearing combined: FCB, RCB and FCBN.

1. The unique structure of the drawn cup outer ring makes the clutch lightweight and compact.
2. The height of the cross-section is the same as standard drawn cup needle bearings and the torque capacity is high.
3. Performance is accurate and friction torque is low during overrunning.
4. Installation can be done in the same way as for drawn cup needle bearings, that is, by simply press fitting the unit into the housing.

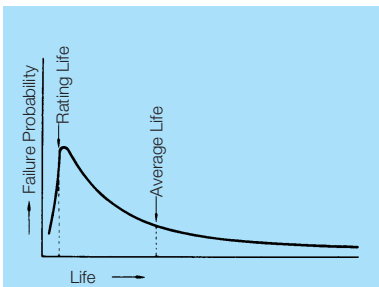




## 2. Bearing Life and Basic Load Rating

### 2.1 Bearing Life

Like other rolling bearings, needle roller bearings cannot be used forever and can fracture for various reasons. If bearings are incorrectly mounted, lubrication is improper or bearings are exposed to dust and moisture due to poor sealing, they will eventually fail to perform satisfactorily. Even if bearings are properly mounted and operated correctly with sufficient lubrication, when rolling bearings are operated under load, the inner and outer ring raceways and rolling elements are subjected to repeated cyclic stress. Because of metal fatigue of the rolling contact surfaces of the raceways and rolling elements, scaly particles may separate from the bearing material. This phenomenon is called “flaking”. Bearing fatigue life is defined by the total number of revolutions after which the bearing surface will start flaking due to stress. If the speed is constant, the fatigue life is often expressed by the total number of operating hours. As shown in **Fig. 2.1**, even for seemingly identical bearings, which are of the same type, size and material, and receive the same heat treatment and other processing, the rolling fatigue life varies greatly even under identical operating conditions. This is because the flaking of materials due to fatigue is subject to many other variables. Consequently, “rating fatigue life” is used in preference to actual rolling fatigue life. Suppose a number of bearings of the same type are operated individually under the same



**Fig. 2.1**  
Failure Probability and Bearing Life

conditions. After a certain period of time, 10% of them fail as a result of flaking caused by rolling fatigue. The total number of revolutions at this point is defined as the basic rating life or, if the speed is constant, the basic rating life is often expressed by the total number of operating hours completed.

### 2.2 Basic Dynamic Load Rating

The basic load rating is defined as the constant load applied on bearings with stationary outer rings that the inner rings or shafts can endure for a rating life of one million revolutions ( $10^6$  rev). The basic load rating of radial bearings is defined as a central radial load of constant direction and magnitude, while the basic load rating of thrust bearings is defined as an axial load of constant magnitude in the same direction as the central axis. The basic load ratings of roller bearings are defined in ISO 281 and can be calculated by Equation **2.1** and **2.2**. The basic load ratings  $C_r$  and  $C_a$  listed in the dimension tables of NSK needle bearings are calculated in accordance with ISO, but amended with development of bearing materials and manufacturing quality.

$$C_r = b_m f_c (i L_{we} \cos \alpha)^{\frac{7}{9}} Z^{\frac{3}{4}} D_w^{\frac{29}{27}} \dots \dots \dots (2.1)$$

For thrust roller bearings

$$C_a = b_m f_{ca} L_{we}^{\frac{7}{9}} Z^{\frac{3}{4}} D_w^{\frac{29}{27}} \dots \dots \dots (2.2)$$

where,  $C_r, C_a$  : Basic dynamic load rating (N) {kgf}

- $i$  : Number of roller rows per bearing
- $\alpha$  : Nominal contact angle
- $Z$  : Number of rolling elements per row
- $D_w$  : Roller diameter
- $L_{we}$  : Effective length of roller
- $b_m$  : Rating factor depending on normal material and manufacture quality
- $f_c, f_{ca}$  : Coefficients determined by contact surface shape between roller and bearing ring, processing accuracy and bearing material

### 2.3 Life Equation

The following relation exists between the basic dynamic load rating, the bearing load and the rating fatigue life of roller bearings:

$$L = \left(\frac{C_r}{P}\right)^{\frac{10}{3}} \text{ or } L = \left(\frac{C_a}{P}\right)^{\frac{10}{3}} \dots \dots \dots (2.3)$$

- where,  $L$  : Rating fatigue life ( $10^6$ -revolution unit)
- $P$  : Bearing load (equivalent load) (N), {kgf}
- $C_r, C_a$  : Basic dynamic load rating of radial bearing and thrust bearing (N), {kgf}

When the bearing is rotating at a certain speed  $n$  ( $\text{min}^{-1}$ ), it is convenient to express the fatigue life of the bearing in hours. When fatigue life is expressed in hours, 500 hours is referred to as standard,

$$33.3 \text{min}^{-1} \times 60 \text{min} \times 500 \text{h} = 10^6 \text{rev}$$

In other words, the basic dynamic load rating  $C_r$ , which gives a life of  $10^6$  revolutions, gives the life of 500 hours at  $33.3 \text{min}^{-1}$

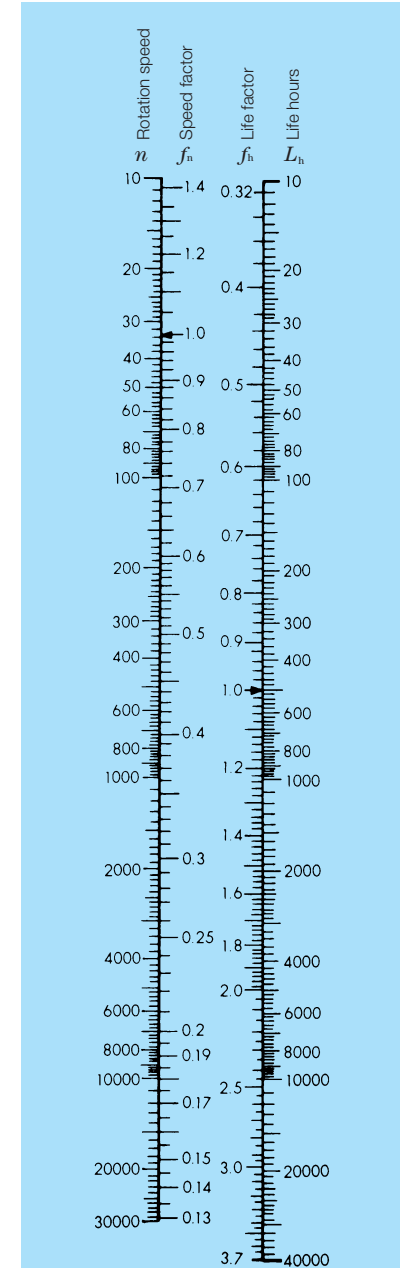
- $L_h$  : Fatigue life hours of bearing (h)  
.....As shown in **Fig. 2.2** and **Appendix 13**
- $f_h$  : Fatigue life factor  
.....As shown in **Fig. 2.2** and **Appendix 13**
- $f_n$  : Speed factor  
.....As shown in **Fig. 2.2** and **Appendix 12**

With the above, the relation between equations **2.4**, **2.5** and **2.6** is obtained.

$$L_h = 500 f_h^{\frac{10}{3}} \dots \dots \dots (2.4)$$

$$f_h = f_n \cdot \frac{C_r}{P} \text{ or } f_h = f_n \cdot \frac{C_a}{P} \dots \dots \dots (2.5)$$

$$f_n = \left(\frac{33.3}{n}\right)^{\frac{3}{10}} \dots \dots \dots (2.6)$$



**Fig. 2.2** Speed Factor and Life Factor

**2.3.1 Temperature Adjustment for Basic Dynamic Load Rating**

If rolling bearings are used at high temperature, the hardness of the bearing steel decreases. Consequently, the basic load rating, which depends on the physical properties of the material, also decreases. Therefore, the basic load rating should be adjusted for higher temperatures using the following equation.

$$C_t = f_t \cdot C \dots\dots\dots(2.7)$$

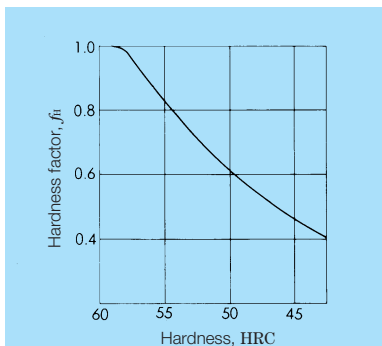
where,  $C_t$  : Basic load rating after temperature correction (N), {kgf}  
 $f_t$  : Temperature factor (See Table 2.1)  
 $C$  : Basic load rating before temperature adjustment (N), {kgf}

**Table 2.1 Temperature Factor,  $f_t$**

Bearing Temperature	°C	125	150	175	200	250
Temperature Factor	$f_t$	1.00	1.00	0.95	0.90	0.75

**2.3.2 Hardness Factor,  $f_H$**

The raceway surface should be HRC58 to 64 and hardened to the proper depth. Methods for hardening the raceway surface include full hardening, carburized hardening or induction hardening. A decrease in hardness results in a



**Fig. 2.3 Hardness Factor**

rapid reduction in the fatigue life of the bearing. When hardness is lower than HRC58, it is necessary to correct the basic dynamic load rating by multiplying it by the hardness factor,  $f_H$ , shown in **Fig. 2.3**.

**2.3.3 Correction of Basic Rating Life**

As described previously, the equation for calculating the basic rating life of roller bearings is:

$$L_{10} = \left( \frac{C}{P} \right)^{\frac{10}{3}} \dots\dots\dots(2.8)$$

The  $L_{10}$  Life is defined as the basic rating life with a statistical reliability of 90%. Depending on the machines in which the bearings are used, sometimes a reliability higher than 90% may be required.

However, recent improvements in bearing material have greatly extended the fatigue life. In addition, the development of the Elasto-Hydrodynamic Theory of Lubrication proves that the thickness of the lubricating film in the contact zone between rings and rolling elements greatly influences bearing life. To reflect such improvements in the calculation of fatigue life, the basic rating life is adjusted using the following adjustment factors:

$$L_{na} = a_1 a_2 a_3 L_{10} \dots\dots\dots(2.9)$$

where,  $L_{na}$  : Adjusted rating life in which reliability, material improvements, lubricating condition, etc. are considered  
 $L_{10}$  : Basic rating life with a reliability of 90%  
 $a_1$  : Life adjustment factor for reliability  
 $a_2$  : Life adjustment factor for special bearing properties  
 $a_3$  : Life adjustment factor for operating conditions

The life adjustment factor for reliability,  $a_1$ , is listed in **Table 2.2** for reliabilities higher than 90%.

The life adjustment factor for special bearing properties,  $a_2$ , is greater than one because of

improvements in bearing steel.

NSK now uses vacuum degassed bearing steel, and the results of tests by NSK show that life is greatly improved when compared with earlier materials. The basic load ratings  $C_t$  and  $C_a$  listed in the bearing tables were calculated considering the extended life achieved by improvements in materials and manufacturing techniques. Consequently, when estimating life using Equation 2.9, it is sufficient to assume  $a_1 = 1$ .

**Table 2.2 Reliability Factor,  $a_1$**

Reliability (%)	90	95	96	97	98	99
$a_1$	1.00	0.62	0.53	0.44	0.33	0.21

The life adjustment factor for operating conditions,  $a_3$ , is used to adjust for various factors, particularly lubrication. If there is no misalignment between the inner and outer rings and the thickness of the lubricating film in the contact zones of the bearing is sufficient, it is possible for  $a_3$  to be greater than one; however,  $a_3$  is less than one in the following cases:

- When the viscosity of the lubricant in the contact zones between the raceways and rolling elements is low.
- When the circumferential speed of the rolling elements is very slow.
- When the bearing temperature is high.
- When the lubricant is contaminated by water or foreign matter.
- When misalignment of the inner and outer rings is excessive.

It is difficult to determine the proper value for  $a_3$  for specific operating conditions because there are still many unknowns. Since the special bearing property factor  $a_2$  is also influenced by the operating conditions, there is a proposal to combine  $a_2$  and  $a_3$  into one quantity ( $a_2 \times a_3$ ), and not consider them independently. In this case, under normal lubricating and operating conditions, the product ( $a_2 \times a_3$ ) should be assumed equal to one. However, if the viscosity of the lubricant is too low, the value drops to as low as 0.2.

If there is no misalignment and a lubricant with high viscosity is used so sufficient fluid-film thickness is secured, the product of ( $a_2 \times a_3$ ) can be as high as two.

When selecting a bearing based on the basic load rating, it is best to choose a reliability factor ( $a_1$ ) appropriate for the projected use and an empirically determined  $C/P$  or  $f_H$  value derived from past results for lubrication, temperature, mounting conditions, etc. in similar machines.

**2.4 Static Load Rating**

**2.4.1 Static Load Ratings**

When subjected to an excessive load or a strong shock load, rolling bearings may incur a local permanent deformation of the rolling elements and permanent deformation of the rolling elements raceway surface if the elastic limit is exceeded. The nonelastic deformation increases in area and depth as the load increases, and when the load exceeds a certain limit, the smooth running of the bearing is impeded.

The basic static load rating is defined as that static load which produces the following calculated contact stress at the center of the contact area between the rolling element subjected to the maximum stress and the raceway surface.

For roller bearings 4 000 MPa{408 kgf/mm<sup>2</sup>}

In this most heavily stressed contact area, the sum of the permanent deformation of the rolling element and that of the raceway is nearly 0.0001 times the rolling element's diameter. The basic static load rating  $C_0$  is written  $C_{0r}$  for radial bearings and  $C_{0a}$  for thrust bearings in the bearing tables.

In addition, following the modification of the criteria for basic static load rating by ISO, the new  $C_0$  values for NSK's roller bearings became about 1.5 to 1.9 times the past values. Consequently, the values of the permissible static load factor,  $f_s$ , have also changed, so please pay attention to this.

**2.4.2 Permissible Static Load Factor**

The permissible static equivalent load on bearings varies depending on the basic static load rating and also the application and operating conditions.

The permissible static load factor,  $f_s$ , is a safety factor that is applied to the basic static load rating, and it is defined by the ratio in Equation 2.10. The generally recommended values of  $f_s$  are listed in Table 2.3. Conforming to the modification of the static load rating, the values of  $f_s$  were revised, especially for bearings for which the values of  $C_0$  were increased, please keep this in mind when selecting bearings.

$$f_s = \frac{C_0}{P_0} \dots\dots\dots(2.10)$$

where,  $C_0$  : Basic static load rating (N), {kgf}  
 $P_0$  : Static equivalent load (N), {kgf}

**Table 2.3 Values of Permissible Static Load Factor,  $f_s$**

Operating Conditions	Lower Limit of $f_s$
Low-noise applications	3
Bearings subjected to vibration and shock loads	2
Standard operating conditions	1.5

**2.5 Maximum Permissible Load of Drawn Cup Needle Roller Bearings  $P_{max}$**

The drawn cup (outer ring) of a needle bearing is made of a thin-wall special steel sheet that is hardened by carburizing after press-forming. Dynamic loads beyond the maximum permissible load,  $P_{max}$ , in the Bearing Tables should not be imposed. For static loads, the permissible load is up to 1.3 times  $P_{max}$ .

**3. Bearing Loads**

**3.1 Equivalent Load**

While in some cases the loads applied to bearings are purely radial or axial loads, in most cases the loads are a combination of both. In addition, loads usually fluctuate in both magnitude and direction. For this reason, the loads actually applied to bearings cannot be used for bearing life calculations. A hypothetical load that has a constant magnitude and passes through the center of the bearing (and will give the same bearing life that the bearing would attain under actual conditions of load and rotation) should therefore be estimated. Such a hypothetical load is called the equivalent load.

In the case of radial needle bearings, as the only load that can be applied is radial, the dynamic equivalent load can be obtained from the following equation:

$$P = F_r \dots\dots\dots(3.1)$$

where,  $P$  : Dynamic equivalent load (N), {kgf}  
 $F_r$  : Radial load imposed on bearing (N), {kgf}

**3.2 Calculation of Bearing Loads**

The loads applied to bearings generally include the weight of the body to be supported by the bearings, the weight of the revolving elements themselves, the transmission power of gears and belting and the load produced by the operation of the machine in which the bearings are used. These loads can be theoretically calculated, but some of them are difficult to estimate. Therefore, it becomes necessary to correct the estimates using empirically derived data.

**3.2.1 Load Factor**

When a radial or axial load has been mathematically calculated, the actual load on the bearing may be greater than the calculated load because of vibration and shock present during operation of the machine. Actual loads may be calculated using the following equations:

$$\left. \begin{aligned} F_r &= f_w \cdot F_{rc} \\ F_a &= f_w \cdot F_{ac} \end{aligned} \right\} \dots\dots\dots(3.2)$$

where,  $F_r, F_a$  : Loads applied on bearing (N), {kgf}  
 $F_{rc}, F_{ac}$  : Theoretically calculated load (N), {kgf}  
 $f_w$  : Load factor

The values given in Table 3.1 are usually used for the load factor,  $f_w$

**Table 3.1 Values of Load Factor,  $f_w$**

Operating Conditions	Typical Applications	$f_w$
Smooth operation free from shock	Electric motors, Machine tools, Air conditioners	1 to 1.2
Normal operation	Air blowers, Compressors, Elevators, Cranes, Papermaking machines	1.2 to 1.5
Operation accompanied by shock and vibration	Construction equipment, Crushers, Vibrating screens, Rolling mills	1.5 to 3

**3.2.2 Bearing Loads in Belt or Chain Transmission Applications**

The force acting on the pulley or sprocket wheel when power is transmitted by a belt or chain is calculated using the following equations:

$$\left. \begin{aligned} M &= 9\,550\,000H/n \dots\dots\{N \cdot mm\} \\ &= 974\,000H/n \dots\dots\{kgf \cdot mm\} \end{aligned} \right\} \dots\dots\dots(3.3)$$

$$P_k = M/r \dots\dots\dots(3.4)$$

where,  $M$  : Torque acting on pulley or sprocket wheel (N•mm), {kgf•mm}  
 $P_k$  : Effective force transmitted by belt or chain (N), {kgf}  
 $H$  : Power transmitted (kW)  
 $n$  : Speed (min<sup>-1</sup>)  
 $r$  : Effective radius of pulley or sprocket wheel (mm)

When calculating the load on a pulley shaft, the belt tension must be included. Thus, to

calculate the actual load,  $K_b$ , in the case of a belt transmission, the effective transmitting power is multiplied by the belt factor,  $f_b$ , which represents the belt tension. Values of  $f_b$  for different types of belts are shown in **Table 3.2**.

$$K_b = f_b \cdot P_k \dots\dots\dots(3.5)$$

In the case of a chain transmission, the values corresponding to  $f_b$  should be 1.25 to 1.5.

**Table 3.2 Belt Factor,  $f_b$**

Type of Belt	$f_b$
Toothed belts	1.3 to 2
V belts	2 to 2.5
Flat belts with tension pulleys	2.5 to 3
Flat belts	4 to 5

**3.2.3 Bearing Loads in Gear Transmission Applications**

The loads imposed on gears in gear transmissions vary according to the type of gear. In the simplest case of spur gears, the load is calculated as follows:

$$M = 9\,550\,000H/n \dots\dots(N \cdot mm) \left. \begin{array}{l} \\ = 974\,000H/n \dots\dots\{kgf \cdot mm\} \end{array} \right\} \dots\dots(3.6)$$

$$P_k = M/r \dots\dots\dots(3.7)$$

$$S_k = P_k \tan \theta \dots\dots\dots(3.8)$$

$$K_c = \sqrt{P_k^2 + S_k^2} = P_k \sec \theta \dots\dots\dots(3.9)$$

- where,  $M$  : Torque applied to gear (N·mm), {kgf·mm}
- $P_k$  : Tangential force on gear (N), {kgf}
- $S_k$  : Radial force on gear (N), {kgf}
- $K_c$  : Combined force imposed on gear (N), {kgf}
- $H$  : Power transmitted (kW)
- $n$  : Speed (min<sup>-1</sup>)
- $r$  : Pitch circle radius of drive gear (mm)
- $\theta$  : Pressure angle

In addition to the theoretical load calculated above, vibration and shock (which depend on how accurately the gear is finished) should be included by multiplying the theoretically calculated load by the gear factor,  $f_g$ .

The values of  $f_g$  should generally be those in **Table 3.3**. When vibration from other sources accompanies gear operation, the actual load is obtained by multiplying the load factor by this gear factor.

**Table 3.3 Values of Gear Factor,  $f_g$**

Gear Finish Accuracy	$f_g$
Precision ground gears	1 to 1.1
Ordinary machined gears	1.1 to 1.3

**3.3 Average Load**

**3.3.1 Average of Fluctuating Load**

When the load applied to bearings fluctuates, an average load that will yield the same bearing life as the fluctuating load should be calculated.

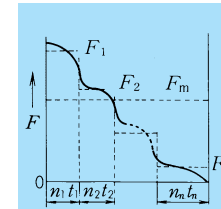
- (1) When the relation between load and rotating speed is divided into the following steps (**Fig. 3.1**):

- Load  $F_1$  : Speed  $n_1$ ; Operating time  $t_1$
- Load  $F_2$  : Speed  $n_2$ ; Operating time  $t_2$
- ⋮
- Load  $F_n$  : Speed  $n_n$ ; Operating time  $t_n$

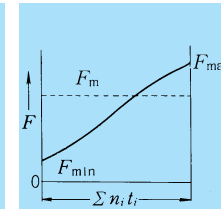
Then, the average load,  $F_m$ , may be calculated using the following equation:

$$F_m = \sqrt{\frac{F_1^{10/3} n_1 t_1 + F_2^{10/3} n_2 t_2 + \dots + F_n^{10/3} n_n t_n}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}} \dots\dots\dots(3.10)$$

where,  $F_m$  : Average fluctuating load (N), {kgf}



**Fig. 3.1 Incremental Load Variation**

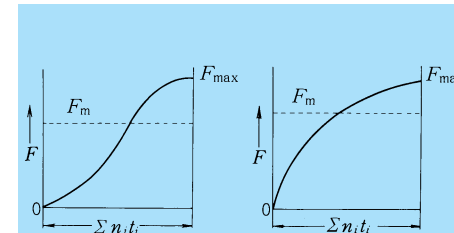


**Fig. 3.2 Simple Load Fluctuation**

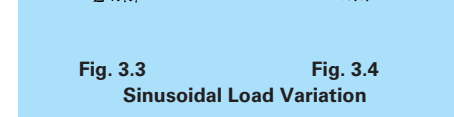
- (2) When the load fluctuates almost linearly (**Fig. 3.2**), an approximate value for the average load may be calculated as follows:

$$F_m \doteq \frac{1}{3} (F_{min} + 2F_{max}) \dots\dots\dots(3.11)$$

- where,  $F_{min}$ : Minimum value of fluctuating load (N), {kgf}
- $F_{max}$ : Maximum value of fluctuating load (N), {kgf}



**Fig. 3.3 Sinusoidal Load Variation**



**Fig. 3.4 Sinusoidal Load Variation**

- (3) When the load fluctuation is similar to a sine wave, an approximate value for the average load may be calculated from the following equation:

In the case of **Fig. 3.3**

$$F_m \doteq 0.65F_{max} \dots\dots\dots(3.12)$$

In the case of **Fig. 3.4**

$$F_m \doteq 0.75F_{max} \dots\dots\dots(3.13)$$

## 4. Bearing Selection

### 4.1 Bearing Types

It is important to select the needle roller bearing that is most suited to the particular application. One must fully understand the structure and characteristics of a selected bearing to determine whether it is appropriate for a given application.

When selecting needle bearings, the following factors should be considered:

- (1) Amount, direction and condition of bearing load
- (2) Rotating speed and which ring is rotating
- (3) Required bearing life
- (4) Ambient temperature of bearing
- (5) Accuracy of bearings
- (6) Degree of friction
- (7) Noise
- (8) Vertical shaft or horizontal shaft
- (9) Lubricating method and sealing device
- (10) Mounting and dismounting
- (11) Space for mounting
- (12) Finishing accuracy, rigidity, and materials of shaft and housing
- (13) Cost requirements

Weighing these factors along with the characteristics of specific bearings, the best bearing for a particular application can be selected.

The characteristics of various NSK needle roller bearings are compared in **Table 4.1**.

#### 4.1.1 Comparison of Bearings with Cages and Full Complement Bearings

Comparing bearings of the same size, full complement bearings, both at rest and when rotating, have a higher load rating and maximum permissible load than bearings with cages, and are therefore preferred for most applications.

As the rollers are accurately guided in bearings with a cage and no friction occurs between the rollers, the friction torque is lower than in the full complement roller bearings.

Under ideal lubrication conditions and normal load, approximate friction torque can be obtained with the following equation.

Friction torque of a full complement roller bearing:

$$0.0025 \times \frac{\text{pitch circle radius}}{\text{of rollers}} \times \frac{\text{bearing load}}{\text{load}}$$

Friction torque of cage assembly:

$$0.0015 \times \frac{\text{pitch circle radius}}{\text{of rollers}} \times \frac{\text{bearing load}}{\text{load}}$$

While full complement roller bearings can be operated at considerably high speeds (see the limiting speeds shown in the Bearing Tables), bearings with cages are recommended for high-speed applications. Bearings with cages are also preferable for applications where shaft deflection or mounting error is relatively high because their rollers are accurately guided and crowned.

#### 4.1.2 Comparison between Drawn Cup and Solid Bearings

Employing a thick, hardened bearing ring, solid bearings can sustain high shock loads and continuous loads. Drawn cup bearings are not to be used beyond the maximum permissible load shown in the Bearing Tables.

Although solid bearings of high rigidity can be used with double-cut, split housings, drawn cup bearings are affected by bore accuracy and housing rigidity due to their thin outer ring. Therefore, double-cut, split housings should be avoided.

When mounting solid bearings, positioning is required to be in line with the shoulder of the housing hole or a snap ring. However, with drawn cup bearings, as through-holes are sufficient for housings, bore processing is easier and more economical.

**Table 4.1 Comparison of Characteristics of Needle Roller Bearings**

Bearing Type	Cage & Needle Rollers	Drawn Cup		Solid	Thrust	Needle Roller	Cam Follower/ Roller Follower	
		With Cage	Full Complement	With Cage	Needle		With Cage	Full Complement
		FWJ, WJ, FBN, etc.	FJ, FJL, J, JH, etc.	F, B, BH, etc.	RNA, HJ, RLM, etc.		FNTA, NTA	FCJ, FYCJ
Characteristics								
Radial Load Capacity	High	Medium	High	High	None	Very high	Medium	High
Axial Load Capacity	None	None	None	None	High	None	None	None
Maximum Permissible Load	High	Low	Low	High	High	Very high	Low	Low
Limiting Speed	Very high	Very high	Medium	Very high	High	Medium	High	Low
Permissible Shaft Deflection and Mounting Error	Medium	Medium	Low	Medium	Low	Low	Medium	Low
Grease Life	Very high	Very high	Medium	Very high	Low	Medium	High	Low
Friction Torque	Very low	Very low	Low	Very low	Low	Low	Very low	Low
Cross-Section Height	Very low	Very low	Very low	Medium	Very low	Very low	Medium	Medium
Cost performance	High	High	High	Moderate	High	Very high	Moderate	Moderate

**Table 4.2 Fatigue Life Factors,  $f_{ih}$ , for Various Bearing Applications**

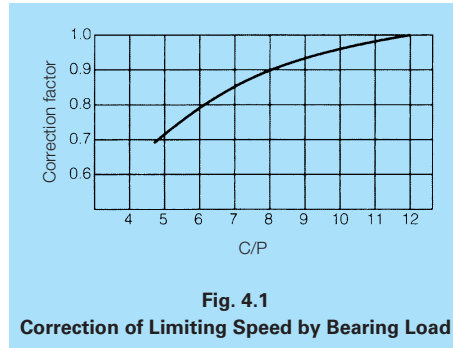
Operating Periods	Fatigue Life Factor, $f_{ih}$				
	≤ 3	2 to 4	3 to 5	4 to 7	≥ 6
Infrequently used or only for short periods	<ul style="list-style-type: none"> <li>Small motors for home appliances like vacuum cleaners and washing machines</li> <li>Hand power tools</li> </ul>	<ul style="list-style-type: none"> <li>Agricultural equipment</li> </ul>			
Used only occasionally but reliability is important		<ul style="list-style-type: none"> <li>Motors for home heaters and air conditioners</li> <li>Construction equipment</li> </ul>	<ul style="list-style-type: none"> <li>Conveyors</li> <li>Elevator cable sheaves</li> </ul>		
Used intermittently for relatively long periods	<ul style="list-style-type: none"> <li>Rolling mill roll necks</li> </ul>	<ul style="list-style-type: none"> <li>Small motors</li> <li>Deck cranes</li> <li>General cargo cranes</li> <li>Pinion stands</li> <li>Passenger cars</li> </ul>	<ul style="list-style-type: none"> <li>Factory motors</li> <li>Machine tools</li> <li>Transmissions</li> <li>Vibrating screens</li> <li>Crushers</li> </ul>	<ul style="list-style-type: none"> <li>Crane sheaves</li> <li>Compressors</li> <li>Specialized transmissions</li> </ul>	
Used intermittently for more than eight hours daily		<ul style="list-style-type: none"> <li>Escalators</li> </ul>	<ul style="list-style-type: none"> <li>Centrifugal separators</li> <li>Air conditioning equipment</li> <li>Blowers</li> <li>Woodworking machines</li> <li>Large motors</li> <li>Axle boxes on railway rolling stock</li> </ul>	<ul style="list-style-type: none"> <li>Mine hoists</li> <li>Press flywheels</li> <li>Railway traction motors</li> <li>Locomotive axle boxes</li> </ul>	<ul style="list-style-type: none"> <li>Papermaking machines</li> </ul>
Used continuously and high reliability is important					<ul style="list-style-type: none"> <li>Waterworks pumps</li> <li>Electric power stations</li> <li>Mine draining pumps</li> </ul>

### 4.2 Machinery in which Bearings are Used and Projected Life

It is not advisable to select bearings with unnecessarily high load ratings, for such bearings may be too large and uneconomical. In addition, the bearing life alone should not be the deciding factor in the selection of bearings. The strength, rigidity, and design of the shaft on which the bearings are to be mounted should also be considered. Bearings are used in a wide range of applications and the design life varies with specific applications and operating conditions. **Table 4.2** gives empirical fatigue life factors derived from operating experience for various applications.

### 4.3 Limiting Speed

Rolling bearings are subject to speed limitations. When bearings are operating, the higher the speed, the higher the bearing



**Fig. 4.1**  
Correction of Limiting Speed by Bearing Load

temperature due to friction. The limiting speed is the empirically obtained value for the maximum speed at which bearings can be continuously operated without failing from seizure or generation of excessive heat. Naturally, limiting speeds (in  $\text{min}^{-1}$ ) vary depending on such factors as bearing type and dimensions, cage type and material, bearing

**Table 4.3** Interchangeable Radial Internal Clearances of Metric Solid Needle Roller Bearings  
unit:  $\mu\text{m}$

Bearing Bore Diameter <i>d</i> (mm)		Clearance									
		C2		CN		C3		C4		C5	
over	incl	min	max	min	max	min	max	min	max	min	max
—	10	0	25	20	45	35	60	50	75	—	—
10	24	0	25	20	45	35	60	50	75	65	90
24	30	0	25	20	45	35	60	50	75	70	95
30	40	5	30	25	50	45	70	60	85	80	105
40	50	5	35	30	60	50	80	70	100	95	125
50	65	10	40	40	70	60	90	80	110	110	140
65	80	10	45	40	75	65	100	90	125	130	165
80	100	15	50	50	85	75	110	105	140	155	190
100	120	15	55	50	90	85	125	125	165	180	220
120	140	15	60	60	105	100	145	145	190	200	245
140	160	20	70	70	120	115	165	165	215	225	275
160	180	25	75	75	125	120	170	170	220	250	300
180	200	35	90	90	145	140	195	195	250	275	330
200	225	45	105	105	165	160	220	220	280	305	365
225	250	45	110	110	175	170	235	235	300	330	395
250	280	55	125	125	195	190	260	260	330	370	440
280	315	55	130	130	205	200	275	275	350	410	485
315	355	65	145	145	225	225	305	305	385	455	535
355	400	100	190	190	280	280	370	370	460	510	600
400	450	110	210	210	310	310	410	410	510	565	665

load, lubricating method, and cooling conditions, including those of the bearing's surroundings. When bearing load, *P*, exceeds 8% of the basic load rating, *C*, the limiting speed shown in the Bearing Tables must be corrected by multiplying it by the correction factor in **Fig. 4.1**.

In the Bearing Tables, the limiting speeds for oil lubrication are shown for each bearing. For grease lubrication, consider 60 to 70% of the oil lubrication values as a guide. Please consult NSK for further details.

### 4.4 Internal Clearance of Rolling Bearings

The internal clearance of rolling bearings during operation is one of the key features affecting bearing characteristics such as life span, heat generation, vibration and noise. Internal clearance is the space between the

raceway ring and the rolling elements. The distance the free ring moves when a specific measured radial load is applied is defined as the radial measured clearance. In roller bearings, since elastic deformation caused by the measured load can be ignored, the measured clearance and geometric clearance (radial internal clearance) are considered to be the same.

Values for the radial internal clearance of metric solid needle bearings with interchangeable components are listed in **Table 4.3**. These are classified from smallest clearance to largest into C2, CN, C3, C4 and C5. When the clearance range of bearings with interchangeable rings is too wide, matched bearings with the clearances listed in **Table 4.4** (page A23) are available.

The radial internal clearances of inch needle bearings with inner rings, HJ + IR, are shown in **Table 4.5** (page A25). HJ + IR needle bearings

**Table 4.4** Matched Radial Internal Clearance of Metric Solid Needle Roller Bearings  
unit:  $\mu\text{m}$

Bearing Bore Diameter <i>d</i> (mm)		Clearance									
		CC2		CC		CC3		CC4		CC5	
over	incl	min	max	min	max	min	max	min	max	min	max
6	10	10	20	20	30	35	45	45	55	—	—
10	14	10	20	20	30	35	45	45	55	65	75
14	18	10	20	20	30	35	45	45	55	65	75
18	24	10	20	20	30	35	45	45	55	65	75
24	30	10	25	25	35	40	50	50	60	70	80
30	40	12	25	25	40	45	55	55	70	80	95
40	50	15	30	30	45	50	65	65	80	95	110
50	65	15	35	35	50	55	75	75	90	110	130
65	80	20	40	40	60	70	90	90	110	130	150
80	100	25	45	45	70	80	105	105	125	155	180
100	120	25	50	50	80	95	125	120	145	180	205
120	140	30	60	60	90	105	135	135	160	200	230
140	160	35	65	65	100	115	150	150	180	225	260
160	180	35	75	75	110	125	165	165	200	250	285
180	200	40	80	80	120	140	180	180	220	275	315
200	225	45	90	90	135	155	200	200	240	305	350
225	250	50	100	100	150	170	215	215	265	330	380
250	280	55	110	110	165	185	240	240	295	370	420
280	315	60	120	120	180	205	265	265	325	410	470
315	355	65	135	135	200	225	295	295	360	455	520
355	400	75	150	150	225	255	330	330	405	510	585
400	450	85	170	170	255	285	370	370	455	565	650

are wide and clearance values are determined broadly based on previous experience to be on the safe side. As the values in **Table 4.3** and **4.4** are also used for cylindrical roller bearings, which are narrower, CN clearance is not commonly used for needle bearings, which are wider and produced in various structures.

Clearance at a certain temperature and under particular rotation conditions, even under conditions where the load causes no elastic deformation, is defined as the effective clearance. Theoretically, bearing life is longest when the effective clearance is slightly negative. It is, however, difficult to operate all bearings under these ideal conditions and if the proper negative clearance is exceeded, bearing life significantly decreases. The effective clearance, therefore, should generally be set as positive. Fitting conditions, temperature conditions and mounting error should be taken into consideration in clearance selection.

**4.4.1 Fitting Condition**

Radial clearance is reduced by expansion or contraction of the bearing rings when fitting either an inner or an outer ring onto a shaft or into a housing with interference. This decreased value, obtained by the calculation shown in **Table 5.1** (page A31), is approximately 75 to 90% of interference.

As the fitting surface is finished with a certain tolerance, it is advisable that calculation of the decreased value in internal clearance due to fitting be dealt with statistically.

**4.4.2 Bearings and Circumference Temperature Conditions**

Frictional heat generated by bearing rotation is released through shafts and housings. Since heat is released more readily through the housing, the temperature of the inner ring and rolling elements is higher than that of the outer ring. This difference in temperature is larger when the shaft is heated or the housing is cooled. Radial internal clearance is reduced by the difference in heat expansion resulting from the temperature difference between the inner and outer rings. The value of this clearance reduction in rolling bearings is calculated by the

following equation:

$$\delta_t \doteq \frac{1}{4} \alpha \Delta_t (3D+d) \dots\dots\dots(4.1)$$

where,  $\delta_t$ : Decreased value of radial internal clearance by temperature difference between inner and outer ring (mm)

$\alpha$ : Coefficient of linear expansion of bearing steel ( $12.5 \times 10^{-6}$ )

$\Delta_t$ : Temperature difference between inner and outer rings (°C)

$D$ : Nominal outside diameter (mm)

$d$ : Nominal bore diameter (mm)

**4.4.3 Shaft Deflection and Mounting Error of Bearings**

When shaft deflection and mounting error are large, it is necessary to select a larger bearing clearance. For metric solid needle bearings, for example, when the fitting of the inner and outer rings is tight (i.e., tighter than the values of **k** and **K**) care should be taken to select a clearance of C3 or CC3 and larger from **Tables 4.3** and **4.4**, in order to prevent insufficient radial internal clearance.

For solid needle bearings, which are often used without an inner ring, various radial internal clearances are obtained by selecting shaft tolerances, as shown in **Table 4.6**.

**Table 4.5 Interchangeable Radial Internal Clearance of Inch Solid Needle Roller Bearings**

Nominal Dimension of Roller's Inscribed Circle Diameter, $F_w$ mm (inch)		Clearance	
		min	max
over	incl		
—	15.875 ( $\frac{5}{8}$ )	33	66
15.875 ( $\frac{5}{8}$ )	25.400 ( 1 )	41	77
25.400 ( 1 )	28.575 ( $1 \frac{1}{8}$ )	46	82
28.575 ( $1 \frac{1}{8}$ )	34.925 ( $1 \frac{3}{8}$ )	48	86
34.925 ( $1 \frac{3}{8}$ )	41.275 ( $1 \frac{5}{8}$ )	50	88
41.275 ( $1 \frac{5}{8}$ )	47.625 ( $1 \frac{7}{8}$ )	50	91
47.625 ( $1 \frac{7}{8}$ )	69.850 ( $2 \frac{3}{4}$ )	56	99
69.850 ( $2 \frac{3}{4}$ )	76.200 ( 3 )	56	104
76.200 ( 3 )	95.250 ( $3 \frac{3}{4}$ )	63	117
95.250 ( $3 \frac{3}{4}$ )	101.600 ( 4 )	68	122
101.600 ( 4 )	114.300 ( $4 \frac{1}{2}$ )	68	127
114.300 ( $4 \frac{1}{2}$ )	139.700 ( $5 \frac{1}{2}$ )	71	132
139.700 ( $5 \frac{1}{2}$ )	152.400 ( 6 )	76	137
152.400 ( 6 )	165.100 ( $6 \frac{1}{2}$ )	76	142
165.100 ( $6 \frac{1}{2}$ )	196.850 ( $7 \frac{3}{4}$ )	84	154
196.850 ( $7 \frac{3}{4}$ )	209.550 ( $8 \frac{1}{4}$ )	84	159
209.550 ( $8 \frac{1}{4}$ )	234.950 ( $9 \frac{1}{4}$ )	87	162

**Note:** For internal clearances other than the values shown in this table, please consult NSK.

**Table 4.6 Fitting Tolerances and Radial Internal Clearance of Shafts Assembled with Solid Needle Roller Bearings without Inner Rings**

Nominal Dimension of Roller's Inscribed Circle Diameter, $F_w$ (mm)		C2	CN	C3	C4
6	180	k5	g5	f6	e6
180	315	j6	f6	e6	d6
315	490	h6	e6	d6	c6

**Note:** For tight fitting of the outer ring (class K and higher) select a smaller shaft dimension in consideration of the contraction of the inscribed circle diameter after assembly.

**4.4.4 Radial Internal Clearance of Drawn Cup Needle Roller Bearings**

Because the correct form and dimensional accuracy of drawn cup needle bearings is achieved only after press fitting into a specific housing bore, the method for selecting the internal clearance of solid needle bearings cannot be applied to drawn cup bearings. Please refer to page B39 for the internal clearances of drawn cup needle bearings.

**4.5 Bearing Accuracy**

NSK needle roller bearings are manufactured in conformity with the accuracy classes set down by ISO. Class 0 is adequate for general use, while bearings with higher accuracy, such as Classes 6, 5, and 4, are recommended for use when extremely low runout is required, when the rotating speed is high, and/or when less friction and shaft fluctuation are required. As various factors, such as bearing type, internal clearance, lubrication, and mounting, should be considered when selecting higher-accuracy bearings, please consult NSK.

As defined by ISO, the boundary dimensions for radial bearings, tolerances for boundary dimensions and running accuracy, and limits for chamfer dimensions are shown in **Table 4.7**. Regarding high-accuracy bearings of Class 6 and higher, please consult NSK.





**Symbols for Boundary Dimensions and Running Accuracy**

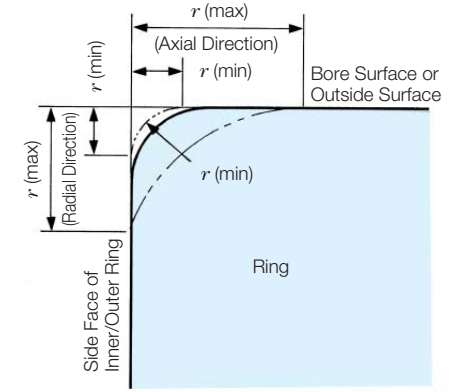
$d$	Nominal bearing bore diameter	$\Delta_{Dmp}$	Single plane mean outside diameter deviation
$\Delta_{ds}$	Deviation of a single bore diameter	$V_{Dp}$	Outside diameter variation in a single radial plane
$\Delta_{dmp}$	Single plane mean bore diameter deviation	$V_{Dmp}$	Mean outside diameter variation
$V_{dp}$	Bore diameter variation in a single radial plane	$\Delta_{Cs}$	Deviation of a single outer ring width
$V_{dmp}$	Mean bore diameter variation	$V_{Cs}$	Outer ring width variation
$\Delta_{Bs}$	Deviation of a single inner ring width	$K_{ca}$	Radial runout of assembled bearing outer ring
$V_{Bs}$	Inner ring width variation	$S_D$	Variation of bearing outside surface generatrix inclination with outer ring reference face (backface)
$K_{ia}$	Radial runout of assembled bearing inner ring		
$S_d$	Inner ring reference face (backface, where applicable) runout with bore		
$D$	Nominal bearing outside diameter		
$\Delta_{Ds}$	Deviation of a single outside diameter		

**Chamfer Dimension Limits (for Metric Design Bearings)**

**Table 4.8.1 Chamfer Dimension Limits for Radial Bearings**

Units: mm

Permissible Chamfer Dimension for Inner/Outer Rings $r$ (min)	Nominal Bore Diameter $d$		Permissible Chamfer Dimension for Inner/Outer Rings $r$ (max)	
	over	incl	Radial Direction	Axial Direction
0.15 0.2	—	—	0.3 0.5	0.6 0.8
0.3	—	40	0.6 0.8	1 1
0.5	—	—	1.2	1.7
0.6	—	40	1 1.3	2 2
1	—	50	1.5 1.9	3 3
1.1	—	120	2 2.5	3.5 4
1.5	—	120	2.3 3	4 5
2	—	80	3	4.5
	80	220	3.5	5
	220	—	3.8	6
2.1	—	280	4	6.5
	280	—	4.5	7
2.5	—	100	3.8	6
	100	280	4.5	6
	280	—	5	7
3	—	280	5	8
	280	—	5.5	8
4	—	—	6.5	9



$r$  : Chamfer Dimension of Inner/Outer Ring

**Remarks** The precise shape of chamfer surfaces has not been specified but its profile in the axial plane shall not intersect an arc of radius  $r$  (min) touching the side face of an inner ring and bore surface, or the side face of an outer ring and outside surface.

**Remarks** For bearings with nominal widths less than 2 mm, the value of  $r$  (max) in the axial direction is the same as that in the radial direction.

## 5. Shaft and Housing Design

The function of the bearing cannot be achieved fully without adequate design of the bearing abutment, even though appropriate bearings can be selected from a wide range of bearing types. In particular, the raceway ring of needle bearings is very thin compared with other roller bearings, so special consideration should be taken regarding shaft and housing design and fitting.

### 5.1 Fitting

#### 5.1.1 Purpose of Fitting

The purpose of fitting is to fix an inner ring or outer ring into the shaft or housing and to prevent harmful circumferential slipping, which is called "creep." Creep between fitting surfaces causes wear and results in abrasive metallic particles entering the bearing, which leads to abnormal temperature rise and vibration. Fitting is also necessary for obtaining the correct form and dimensional accuracy for drawn cup needle bearings.

#### 5.1.2 Type and Volume of Load

It is necessary to know which ring, inner or outer, rotates against the load. In the case of an inner ring rotating load, creep occurs when the fitting between the inner ring and shaft is not tight enough. Because creep cannot be prevented simply by fixing the inner ring axially, the fitting for the inner ring and shaft needs to be tight. However, relatively loose fitting is often employed to make mounting and dismounting easier. In this case, the fitting surfaces must be well lubricated to prevent fretting and scoring.

In the case of an outer ring rotating load, the fitting between the outer ring and housing should be tight. For loads of indeterminate direction, such as unbalanced loads, vibration loads, and irregular dimensional loads, tight fitting of both the inner and outer rings is recommended.

In accordance with the size of the load, the inner ring is compressed in the radial direction and becomes relatively wider while interference decreases. The interference must not, however, be allowed to disappear due to the radial load.

The decrease in interference,  $\Delta d_r$ , is estimated using the following equation:

$$\left. \begin{aligned} \Delta d_r &= 0.08 \sqrt{\frac{d}{B} F_r} \times 10^{-3} \dots\dots(N) \\ \Delta d_r &= 0.25 \sqrt{\frac{d}{B} F_r} \times 10^{-3} \dots\dots\{\text{kgf}\} \end{aligned} \right\} \dots\dots(5.1)$$

where,  $\Delta d_r$ : Decrease in interference of the inner ring (mm)

- $d$ : Nominal bore diameter (mm)
- $B$ : Nominal inner ring width (mm)
- $F_r$ : Radial load applied on bearing (N), {kgf}

#### 5.1.3 Effective Interference and Finish of Shaft and Housing

Since the roughness of fitted surfaces is reduced during fitting, the effective interference becomes less than the apparent interference. The amount of this interference decrease varies depending on the roughness of the surfaces and may be estimated using the following equations:

For ground shafts  $\Delta d \doteq \frac{d}{d+2} \Delta d_a \text{ (mm)}$  .....(5.2)

For machined shafts  $\Delta d \doteq \frac{d}{d+3} \Delta d_a \text{ (mm)}$  .....(5.3)

- where,  $\Delta d$ : Effective interference (mm)
- $\Delta d_a$ : Apparent interference (mm)
- $d$ : Bearing nominal bore diameter (mm)

According to Equations 5.2 and 5.3, the effective interference of bearings with a bore diameter of 30 to 150 mm is about 95% of the apparent interference.

#### 5.1.4 Interference Variation Caused by Temperature Difference between Bearing and Shaft or Housing

The effective interference decreases due to the increasing bearing temperature during operation. If the temperature difference between the bearing and housing is  $\Delta T$  (°C), then the temperature difference between the fitted surfaces of the shaft and inner ring is estimated

	Inner ring and shaft	Outer ring and housing
Surface pressure $p_m$ (MPa) (kgf/mm <sup>2</sup> )	Hollow shaft $p_m = \frac{\Delta d}{d} \left[ \frac{m_s - 1}{m_s E_s} - \frac{m_i - 1}{m_i E_i} \right] + 2 \left[ \frac{k_0^2}{E_c(1 - k_0^2)} + \frac{1}{E_i(1 - k^2)} \right]$ Solid shaft $p_m = \frac{\Delta d}{d} \left[ \frac{m_s - 1}{m_s E_s} - \frac{m_i - 1}{m_i E_i} \right] + \left[ \frac{2}{E_i(1 - k^2)} \right]$	Housing outside diameter $p_m = \frac{\Delta D}{D} \left[ \frac{m_o - 1}{m_o E_o} - \frac{m_h - 1}{m_h E_h} \right] + 2 \left[ \frac{h_0^2}{E_c(1 - h_0^2)} + \frac{1}{E_o(1 - h^2)} \right]$
Expansion of inner ring raceway $\Delta D_i$ (mm) Contraction of outer ring raceway $\Delta D_e$ (mm)	$\Delta D_i = 2d \frac{p_m}{E_i} \frac{k}{1 - k^2}$ $= \Delta d \cdot k \frac{1 - k_0^2}{1 - k^2 k_0^2} \quad (\text{hollow shaft})$ $= \Delta d \cdot k \quad (\text{solid shaft})$	$\Delta D_e = 2D \frac{p_m}{E_o} \frac{1}{1 - h^2}$ $= \Delta D \cdot h \frac{1 - h_0^2}{1 - h^2 h_0^2}$
Maximum stress $\sigma_{t \max}$ (MPa) (kgf/mm <sup>2</sup> )	Circumferential stress at inner ring bore fitting surface is maximum. $\sigma_{t \max} = p_m \frac{1 + k^2}{1 - k^2}$	Circumferential stress at outer ring bore surface is maximum. $\sigma_{t \max} = p_m \frac{2}{1 - h^2}$
Symbols	$d$ : Shaft diameter, inner ring bore $d_0$ : Hollow shaft bore $D_i$ : Inner ring raceway diameter $k = d/D_i$ , $k_0 = d_0/d$ $E_i$ : Inner ring Young's modulus, 208 000 MPa {21 200 kgf/mm <sup>2</sup> } $E_s$ : Shaft Young's modulus $m_i$ : Inner ring poisson's number, 3.33 $m_s$ : Shaft poisson's number	$D$ : Housing bore diameter, outer ring outside diameter $D_0$ : Housing outside diameter $D_e$ : Outer ring raceway diameter $h = D_e/D$ , $h_0 = D_0/D_0$ $E_o$ : Outer ring Young's modulus, 208 000 MPa {21 200 kgf/mm <sup>2</sup> } $E_h$ : Housing Young's modulus $m_o$ : Outer ring poisson's number, 3.33 $m_h$ : Housing poisson's number

to be about (0.1 to 0.15)  $\Delta T$  in case that the shaft is cooled. The decrease in the interference of the inner ring due to this temperature difference  $\Delta d_T$  may be calculated using Equation 5.4:

$$\Delta d_T = (0.10 \text{ to } 0.15) \Delta T \cdot \alpha \cdot d \doteq 0.0015 \Delta T \cdot d \times 10^{-3} \text{ (mm)} \dots\dots(5.4)$$

where,  $\Delta d_T$ : Decrease in interference of inner ring due to temperature difference (mm)

$\Delta T$ : Temperature difference between bearing interior and surrounding parts (°C)

$\alpha$ : Coefficient of linear expansion of bearing steel =  $12.5 \times 10^{-6}$  (1/°C)

$d$ : Nominal bearing bore diameter (mm)

In addition, depending on the temperature difference between the outer ring and housing, or difference in their coefficients of linear expansion, the interference may increase.

#### 5.1.5 Deformation and Stress Caused by Fitting

When mounting a bearing with an interference fit, deformation and stress of the rings result. Calculations of surface pressure, stress, and expansion and contraction of inner and outer rings during fitting are the same as those of a thick cylinder to which is applied internal or external pressure. These calculations are compiled and shown in Table 5.1. The modulus of longitudinal elasticity and Poisson's ratio of shaft and housing are calculated as the inner and outer rings are the

same. Circumferential stress at the inner ring bore surface should be equal to or less than 127 N/mm<sup>2</sup>, {13 kgf/mm<sup>2</sup>}.

**Table 5.1** does not apply to drawn cup needle bearings.

**5.1.6 Recommended Fitting**

As discussed above, selecting appropriate fitting requires knowledge of various conditions such as the actual volume and type of load applied to the bearing, temperature conditions, and other conditions affected by fitting. However, it is very difficult to obtain accurate data for all factors involved. Fitting, therefore, is often determined based on previous experience and records. Standard fittings for needle bearings are shown in **Tables 5.2** and **5.3**. Generally, when mounting a bearing in a thin-wall housing or on a hollow shaft, tighter fitting is required.

A split housing cannot be used with drawn cup needle bearings. If there are no alternatives, a bearing press-fitted into a cylindrical sleeve can be used. It is recommended not to use fitting tighter than that of JS7 (J7) for solid bearings in split housings.

The fitting examples shown in **Tables 5.2** and **5.3** (page A33) can be applied to solid shafts and steel or cast iron thick-wall housings. For mounting needle bearings on hollow shafts and in thin-wall or light metal housings, fitting should be tighter than the values shown in **Tables 5.2** and **5.3**. When higher bearing accuracy is especially required, it is necessary to enhance the accuracy of the shafts and housings.

As correct form and dimensional accuracy of the outer ring of drawn cup needle bearings are obtained only after press fitting into a specific housing bore, please refer to page B40 for fittings for drawn cup needle bearings. However, for the fittings for the inner ring and shaft being used for drawn cup needle bearings, refer to the values in **Table 5.2**.

Tolerances for shafts and housing bore diameters are listed in **Appendices 9** and **10** at the end of this volume.

**Table 5.2 Fittings between Inner Rings and Shafts of Needle Roller Bearings**

	Load Conditions	Examples	Shaft Diameter (mm)	Tolerance of Shaft
Rotating Outer Ring Load	Medium-speed rotation with light or normal load	Wheels on stationary axles, rope sheaves, tension pulleys, idle gears	All shaft diameters	g6
	Medium-speed rotation with heavy load			h6
	Accuracy required			h5
Rotating Inner Ring Load or Indeterminate Directional Load	Light loads (less than or equal to 0.06 C <sub>r</sub> <sup>(1)</sup> )	Electric appliances, precision machinery, machine tools, pumps, blowers, transport vehicles	≤ 18	h5 or js5 (j5)
			≤ 50	js5 (j5)
			From more than 50 to 150	k6
			≥ 150	m6
	Normal loads (0.06 to 0.13 C <sub>r</sub> <sup>(1)</sup> )	General bearings, pumps, main bearings of medium and large engines, woodworking machinery, gears	≤ 50	js5 (j5) or k5
			From more than 50 to 100	m5
			From more than 100 to 150	m6
			From more than 150 to 200	n6
Heavy load (more than 0.13 C <sub>r</sub> <sup>(1)</sup> ) or shock loads	Industrial vehicles, construction equipment, crushers	From more than 50 to 150	n6	
		> 150	p6	

**Note** <sup>(1)</sup> C<sub>r</sub> represents the basic dynamic load rating of each bearing.  
**Remarks** 1. This table is applicable only to solid steel shafts.  
 2. For metric bearings, bearings with clearance larger than CN are used when the fitting is greater than k.

**Table 5.3 Fittings between Solid Needle Roller Bearings and Housing Bores**

	Load Conditions	Examples	Tolerance of Bores
Rotating Outer Ring Load	Light or variable loads	Conveyors, rope sheaves, tension pulleys	M7
	Normal or heavy loads	Wheel hubs, crankshafts, connecting rods	N7
	Heavy shock load	Flywheels	P7
Indeterminate Directional Load	Accurate running under light loads	Main spindles of machine tools	K6
	Light or normal loads	Crankshafts, pumps, compressors, large high-speed gears, blowers	JS7 (J7)
	Normal or Heavy Loads		K7
	Shock loads	Eccentric cams	M7
Rotating Inner Ring Load	Accurate running under light or normal loads	Main spindles of machine tools	JS6 (J6)
	Light or normal load	Gears, plunger blocks	H7
	Loads of all kinds	General applications	H7 or G7
	Shock loads	Industrial vehicles, construction equipment, crushers	JS7 (J7)

**Remarks** 1. This table is not applicable to drawn cup needle bearings.  
 2. This table is applicable to steel and cast iron housings. For light metal housings, fitting should be tighter than in this table.  
 3. For metric bearings, bearings with clearance larger than CN are used when the fitting is greater than K.

## 5.2 Accuracy and Roughness

### 5.2.1 Accuracy and Roughness of Fitting Surfaces

Since the raceway rings of needle bearings are extremely thin, the raceway surface is greatly affected by the accuracy of the shaft and housing. For general operating conditions, a turned finish, smooth bored finish, or reaming finish is acceptable. For high accuracy and low noise under heavy load, however, a grinding finish is required.

A finish roughness of less than  $1.6\mu\text{mRa}$  is desirable. As a split housing may deform the outer ring of a thin-wall needle bearing, care should be exercised with the bearing's finish, such as putting a relief on the machining surface of the mating parts. Accuracy and roughness for machining surfaces are shown in **Table 5.4**.

### 5.2.2 Accuracy and Roughness of the Raceway Surface

The shaft and housing bore are often used as raceway surfaces of needle bearings in order to achieve the most compact bearing design and enhance shaft rigidity, load capacity and accuracy. In this case, accuracy and

roughness of the raceway surface greatly affect the life, noise and accuracy of bearings. Therefore, shape, accuracy and roughness have to be treated with great care. In particular, harmful circumferential waviness and a polygonal shape are not desirable. Accuracy and roughness for raceway surfaces are shown in **Table 5.4**. These values may be changed depending on the desired performance.

### 5.2.3 Shaft Inclination

Shaft inclination caused by external force elastic deflection and mounting error should be less than the values indicated below. If shaft inclination exceeds the values in the table, please consult NSK.

Bearing Width (mm)	Permissible Inclination (mm/mm)	
	With Cage	Full Complement
≤ 25	0.0015	0.0010
(25) to 50	0.0010	0.0005
> 50	0.0005	0.0005

**Table 5.4 Shaft and Housing Specifications of Radial Needle Roller Bearings**  
(Cage & Needle Roller Assemblies/Drawn Cup Bearings/Solid Bearings)

Category	Shaft		Housing Bore	
	Raceway Surface	Fitting Surface	Raceway Surface	Fitting Surface
Out-of-Roundness Tolerance	$\frac{IT3}{2}$	$\frac{IT3}{2}$ to $\frac{IT4}{2}$	$\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Cylindricity Tolerance	$\frac{IT3}{2}$	$\frac{IT3}{2}$ to $\frac{IT4}{2}$	$\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Roughness Ra	0.4	0.8	0.8	1.6
Hardness	HRC58 to 64 (HRC60 to 64 is desirable) Appropriate depth of hardening is required.	—	HRC58 to 64 (HRC60 to 64 is desirable) Appropriate depth of hardening is required.	—

**Remarks** 1. Specifications for shafts and housings of connecting rod cage and roller assemblies are referred to on pages B10 and B11.  
2. For standard tolerances (IT), which are generally recommended according to the radius method, please refer to **Appendix 14** (page C66).

## 5.3 Materials and Heat Treatment of Raceway Surface

The raceway rings and rollers of needle bearings are repeatedly stressed on their relatively small contact surfaces. The materials for raceway rings, rollers and shafts and housings that function as raceways must therefore have high hardness, resistance to permanent deformation and long rolling fatigue life. These materials are also required to be resistant to wear and shock, and have good dimensional stabilization. Common materials used for shafts and housings that function as bearing raceways include:

- High-carbon chromium bearing steel (for through hardening)  
SUJ2 (JIS G 4805)
- Carbon steel for machine construction (for carburizing)  
S15CK (JIS G 4051)
- Chrome molybdenum steel (for carburizing)  
SCM415 to 421 (JIS G 4053)
- Chrome steel (for carburizing)  
SCr415, 420 (JIS G 4053)
- Nickel chrome steel (for carburizing)  
SNC415 to 815 (JIS G 4053)
- Nickel chrome molybdenum steel (for carburizing)  
SNCM220, 415, 420 (JIS G 4053)

Other materials, such as S50C and S55C, can be utilized with through hardening or induction hardening.

The hardened layer, which is tempered at 160 to 180°C after hardening, has to develop a martensite structure that has an even distribution of very fine carbides. In the case of cemented or induction hardening of the raceway surface, the surface hardness should not only be HRC58 to 64 (HRC60 to 64 is preferable), but also the hardened layers with Vickers hardness of HV653 (HRC58) and HV550 (HRC52.3) have to reach appropriate depths. When the values of hardness are below these values, bearing fatigue life significantly decreases (see page A14). The hardened layer depth (up to HV550) after grinding finish is estimated by using the

following equation:

$$t \geq (0.08 \text{ to } 0.10) D_w \dots\dots\dots(5.5)$$

where,  $t$ : Effective hardened layer depth (mm)

$D_w$ : Roller diameter (mm)

Core hardness is generally HRC30 to 45.

## 5.4 Abutment and Fillet Dimensions

The outer ring of solid needle bearings should be positioned in the axial direction using the housing shoulder, collar and snap ring. When mounting, the unmarked side should touch the housing shoulder.

The radius  $r_a$  at the rounded fillet of the housing should be less than the minimum value of the bearing's chamfer dimension  $r$ . When mounting the inner ring on the shaft, the same consideration should be taken (refer to **Table 5.5**).

**Table 5.5 Fillet Radius  $r_a$  of Shaft and Housing**

Units: mm

Minimum Permissible Chamfer Dimension $r$	Fillet Radius $r_a$ of Shaft and Housing (max)
0.15	0.15
0.2	0.2
0.3	0.3
0.5	0.5
0.6	0.6
1	1
1.1	1
1.5	1.5
2	2
2.1	2
2.5	2
3	2.5
4	3

The shoulder height  $h$  should be less than the width of the side face of the outer ring and less than the thickness of the inner ring. It should also have sufficient surface contact. The shaft and housing shoulder need to be finished with a right angle against the shaft center (**Fig. 5.1**).

The marked side of drawn cup needle bearings should be in contact with the mounting jig, and mounted onto the step-less through hole. Drawn cup needle bearings should not be positioned in the axial direction by either a snap ring or collar. The side face of the drawn cup outer ring has to be 0.25 mm or more shorter than the housing's side face in order to

protect the bending part of the outer ring's side face (**Fig. 5.2**).

Other abutment and fillet dimensions are presented in the introductory section for each series. Please refer to the related sections as required.

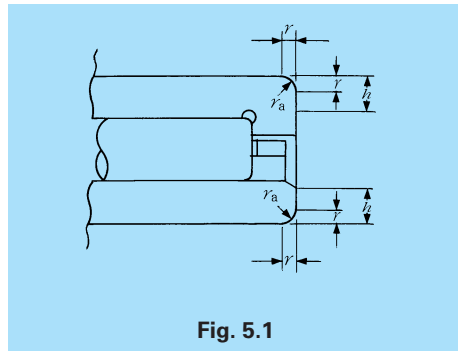


Fig. 5.1

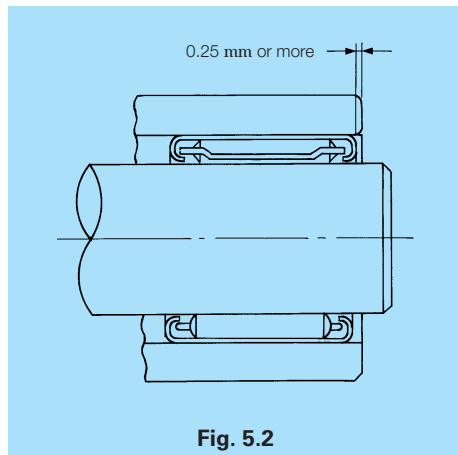


Fig. 5.2

## 6. Lubrication and Lubricating Methods

### 6.1 Friction and Lubrication

Low friction in a bearing means low power loss and temperature rise, which together enable machines to achieve higher speeds. Friction in a machine may vary depending on bearing type, structure, dimensions, as well as the finishing accuracy of the rolling and sliding contact surfaces. It is also influenced by operational conditions, such as bearing load, rotating speed and lubrication. With light load and high-speed rotation, lubrication largely affects the starting torque, while with heavy load and low rotating speed, the load's effect dominates. Torque converts itself into thermal energy causing temperature rise in bearings. The degree of temperature rise is determined by the difference between the amount of heat generated and that dissipated. When bearing temperature exceeds 120°C, the characteristics of the bearing's material are changed and the lubricating agent is deteriorated.

#### 6.1.1 Purposes of Lubrication

The main purposes of lubrication are to reduce friction and wear inside bearings that may cause premature failure. The effects of lubrication may be briefly explained as follows:

##### (1) Reduction of Friction and Wear

In needle bearings, it is necessary to lubricate the area where sliding occurs between the raceway surface and rollers due to roller skew and elastic deformation during operation in order to reduce sliding friction and wear between the cage and rollers, the cage and guide surface of the rotating ring, and the roller end face and the ring's rib face.

##### (2) Extension of Fatigue Life

The rolling fatigue life of bearings depends greatly upon the viscosity and film thickness between the rolling contact surfaces. A heavy film thickness prolongs the fatigue life, but it is shortened if the viscosity of the oil is too low so the film thickness is insufficient.

##### (3) Dissipation of Frictional Heat and Cooling

Circulation lubrication may be used to carry away frictional heat or heat transferred from overheating and the oil from deteriorating.

##### (4) Others

Adequate lubrication also helps to prevent foreign material from entering the bearings and guards against corrosion or rusting.

### 6.2 Lubricants

#### 6.2.1 Lubricating Grease

Grease is a semi-solid lubricant consisting of a base oil and a thickener. The main types and general properties of grease are shown in **Table 6.1**. It should be remembered that different brands of the same type of grease may have different properties.

##### (1) Base Oil

Mineral oils or synthetic oils such as silicone or diester oil are mainly used as the base oil for grease. The lubrication properties of grease depend mainly on the characteristics of its base oil. Therefore, the viscosity of the base oil is just as important when selecting grease as when selecting an oil. Usually, greases made with low-viscosity base oils are more suitable for high speeds and low temperatures, while greases made with high-viscosity base oils are more suited for high temperatures and heavy loads. However, as the thickener also influences the lubricating properties of grease, the selection criteria for grease are not the same as for lubricating oil.

##### (2) Thickener

Thickeners for lubricating grease include several types of metallic soaps, inorganic thickeners such as silica gel and bentonite, and heat-resistant organic thickeners such as polyurea and fluorine compounds. The type of thickener is closely related to the grease dropping point (°): generally, grease with a high dropping point also has high-temperature capability. This said, grease does not have a

**Table 6.1 Grease Properties**

Name (Popular name)	Lithium Grease			Sodium Grease (Fiber Grease)	Calcium Grease (Cup Grease)	Mixed Base Grease
Thickener	Li Soap			Na Soap	Ca Soap	Na+Ca Soap, Li+Ca Soap, etc.
Base Oil	Mineral Oil	Diester Oil, Polyatomic Ester Oil	Silicon Oil	Mineral Oil	Mineral Oil	Mineral Oil
Properties						
Dropping Point, °C	170 to 195	170 to 195	200 to 210	170 to 210	70 to 90	160 to 190
Working Temperatures, °C	-20 to +110	-50 to +130	-50 to +160	-20 to +130	-20 to +60	-20 to +80
Working Speed, % (1)	70	100	60	70	40	70
Mechanical Stability	Good	Good	Good	Good	Poor	Good
Pressure Resistance	Fair	Fair	Poor	Fair	Poor	Fair to Good
Water Resistance	Good	Good	Good	Poor	Good	Poor for Na Soap Grease
Rust Prevention	Good	Good	Poor	Poor to Good	Good	Fair to Good
Remarks	General purpose grease used for numerous applications	Good low temperature and torque characteristics. Often used for small motors and instrument bearings. Pay attention to rust caused by insulation varnish.	Mainly for high-temperature applications. Unsuitable for bearings for high and low speeds or heavy loads or those having numerous sliding-contact areas (roller bearings, etc.)	Long and short fiber types are available. Long fiber grease is unsuitable for high speeds. Attention to water and high temperature is required.	Extreme pressure grease containing high-viscosity mineral oil and extreme pressure additive (Pb soap, etc.) has high pressure resistance.	Often used for roller bearings and large ball bearings.

**Note** (1) The values listed are percentages of the limiting speeds given in the bearing tables.  
**Remarks** The grease properties shown here can vary between brands.

**Table 6.2 Consistency and Working Conditions**

Consistency Number	0	1	2	3	4
Consistency (1) 1/10 mm	355 to 385	310 to 340	265 to 295	220 to 250	175 to 205
Working Conditions (Application)	<ul style="list-style-type: none"> <li>For centralized oiling</li> <li>When fretting is likely to occur</li> </ul>	<ul style="list-style-type: none"> <li>For centralized oiling</li> <li>When fretting is likely to occur</li> <li>For low temperature</li> </ul>	<ul style="list-style-type: none"> <li>For general use</li> </ul>	<ul style="list-style-type: none"> <li>For general use</li> <li>For high temperature</li> </ul>	<ul style="list-style-type: none"> <li>For high temperature</li> <li>For grease seals</li> </ul>

**Note** (1) Consistency: Depth into grease attained by a cone when pressed with a specified weight, indicated in units of 1/10 mm. The larger the value, the softer the grease.

Complex Grease	Non-Soap Based Grease (Non-Soap Grease)	
Ca Complex Soap, Al Complex Soap, Li Complex Soap, etc.	Urea, Bentonite, Carbon Black, Fluoric Compounds, Heat Resistant Organic Compound, etc.	
Mineral Oil	Mineral Oil	Synthetic Oil (Ester Oil, Polyatomic Ester Oil, Synthetic Hydrocarbon Oil, Silicone Oil, Fluoric Oil)
180 to 300	≥230	≥230
-20 to +130	-10 to +130	≤ +220
70	70	40 to 100
Good	Good	Good
Fair to Good	Fair	Fair
Good	Good	Good
Fair to Good	Fair to Good	Fair to Good
Suitable for extreme pressures mechanically stable	Mineral oil base grease is middle and high temperature purpose lubricant. Synthetic oil base grease is recommended for low or high temperature. Some silicone and fluoric oil-based greases have poor rust prevention and noise performance.	

high working temperature unless its base oil is heat-resistant. The highest possible working temperature for grease should be determined considering the heat resistance of the base oil. The water resistance of grease depends upon the type of thickener. Sodium soap grease or compound grease containing sodium soap emulsifies when exposed to water or high humidity and therefore cannot be used where moisture is prevalent.

**Note** (1) The grease dropping point is that temperature at which a grease heated in a specified small container becomes sufficiently fluid to drip.

**(3) Additives**

Grease often contains various additives such as antioxidants, corrosion inhibitors, and extreme pressure additives to give it special properties. It is recommended that extreme pressure additives be used in heavy load applications. For long use without

replenishment, an antioxidant should be added.

**(4) Consistency**

Consistency refers to the “softness” of grease. **Table 6.2** shows the relation between consistency and working conditions.

**(5) Mixing Different Types of Grease**

In general, different brands of grease must not be mixed. Mixing grease with different types of thickeners may destroy its composition and physical properties. Even if the thickeners are of the same type, possible differences in additives may cause detrimental effects.

**6.2.2 Lubricating Oil**

Highly refined mineral or synthetic oil is used as lubricant for rolling bearings. The first point to consider when selecting lubricating oil is appropriate viscosity. This varies depending on the type of needle bearings. Under regular operating conditions, lubricating oil with a viscosity of 13 mm<sup>2</sup>/s (cSt) or more at the operating temperature should be selected. For thrust bearings, oil with a higher viscosity should be chosen. Generally, higher rotational speeds require lower viscosity and larger loads and larger bearing sizes require higher viscosity.

In addition to proper viscosity, characteristics required of lubricating oil include cleanliness, resistance to corrosion, high lubrication performance, superior oxidation resistance, fluidity at low temperatures and pressure resistance. **Fig. 6.1** shows the temperature-viscosity chart for general oil. The viscosity change at a given operating temperature, as well as the appropriate viscosity can be determined from this curve. The method for selecting lubricating oil under various operating conditions is illustrated in **Table 6.3**.

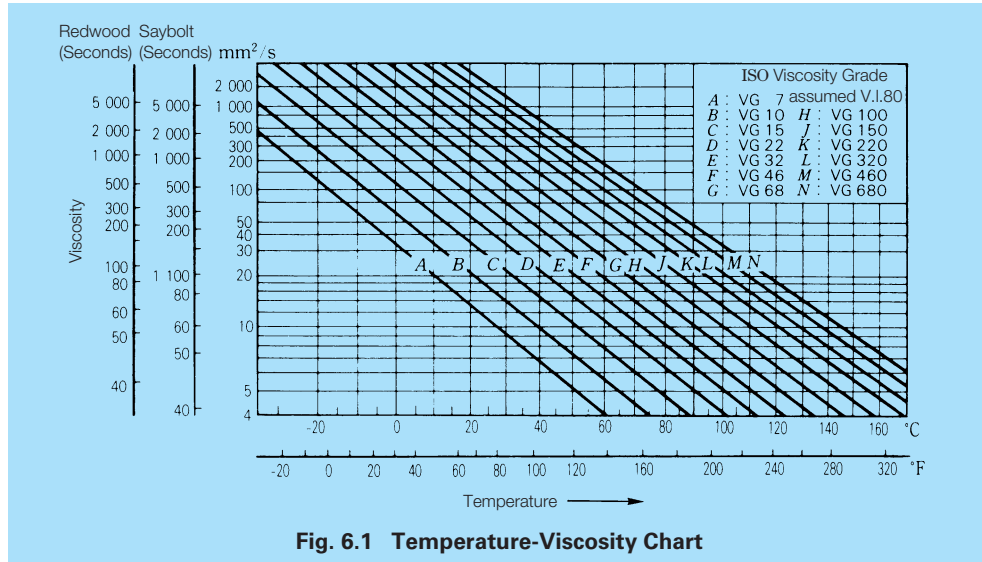


Fig. 6.1 Temperature-Viscosity Chart

Table 6.3 Examples of Selection of Lubricating Oils

Operating Temperature	Speed	Light or Average Load	Heavy or Shock Load
-30 to 0°C	Less than limiting speed	ISO VG 15, 22, 32 (refrigerating machine oil)	—
0 ~ 50°C	Less than 50% of limiting speed	ISO VG 32, 46, 68 (bearing oil, turbine oil)	ISO VG 46, 68, 100 (bearing oil, turbine oil)
	50 to 100% of limiting speed	ISO VG 15, 22, 32 (bearing oil, turbine oil)	ISO VG 22, 32, 46 (bearing oil, turbine oil)
	More than limiting speed	ISO VG 10, 15, 22 (bearing oil)	—
50 ~ 80°C	Less than 50% of limiting speed	ISO VG 100, 150, 220 (bearing oil)	ISO VG 150, 220, 320 (bearing oil)
	50 to 100% of limiting speed	ISO VG 46, 68, 100 (bearing oil, turbine oil)	ISO VG 68, 100, 150 (bearing oil, turbine oil)
	More than limiting speed	ISO VG 32, 46, 68 (bearing oil, turbine oil)	—
80 ~ 110°C	Less than 50% of limiting speed	ISO VG 320, 460 (bearing oil)	ISO VG 460, 680 (bearing oil, gear oil)
	50 to 100% of limiting speed	ISO VG 150, 220 (bearing oil)	ISO VG 220, 320 (bearing oil)
	More than limiting speed	ISO VG 68, 100 (bearing oil, turbine oil)	—

**Remarks**

1. For the limiting speed, use the values listed in the bearing tables.
2. Refer to Refrigerating Machine Oils (JIS K 2211), Bearing Oils (JIS K 2239), Turbine Oils (JIS K 2213), Gear Oils (JIS K 2219).
3. If the operating temperature is near the high end of the temperature range listed in the left column, select a high viscosity oil.
4. If the operating temperature is lower than -30°C or higher than 110°C, it is advisable to consult NSK.

### 6.3 Lubricating Methods

#### 6.3.1 Comparison of Grease Lubrication and Oil Lubrication

The lubrication methods for rolling bearings are generally classified into grease lubrication and oil lubrication. Grease lubrication can last from six months to two years before being replenished. It is therefore ideal for reducing maintenance. However, oil lubrication is preferred if the design allows because of its many advantages over grease, including higher limiting speed, longer lubricant life and better cooling properties. **Table 6.4** compares grease and oil lubrication.

Table 6.4 Comparison of Grease and Oil Lubrication

Item	Grease Lubrication	Oil Lubrication
Limiting Speed	Low and normal speed	All speeds
Lubricating Performance	Good	Superior
Cooling Effect	Poor	Good
Lubricant Life	Relatively short	Relatively long
Change of Lubricant	Complicated	Easy
Seal	Easy	Complicated
Lubricant Leakage	Less	Slightly more
Oil Film Strength	Relatively poor	Good
Filtration of Foreign Matter	Difficult	Easy

#### 6.3.2 Grease Lubrication

With grease lubrication, the internal space in the housing is required to be only 1.5 times the bearing's volume. Generally, the bearing is fully packed with grease before mounting and the amount packed into the housing is 1/4 to 1/3 the volume of the free internal space. When the internal space of the housing is less than 1.5 times the bearing's volume, it is appropriate that the filling amount for the housing be 1/2 to 2/3 the volume of the free space including the bearing itself. Grease should be supplied not only to the space inside the housing, but to the inside of the bearing as well.

If too much grease is supplied, churning of the grease will result and the bearing's temperature will rise. This causes deterioration and softening of the grease resulting in leakage. Generally, once grease is packed, refilling isn't necessary for a long period of time. However, the housing should be designed for easy refilling and changing of grease. When frequent refilling of grease is required, such as at high rotating speeds, a grease nipple should be installed and use of a grease gun for refilling is advisable.

#### 6.3.3 Replenishing Interval

Even if high-quality grease is used, there is deterioration of its properties with time so periodic replenishment is required. **Fig. 6.2** shows the replenishment time intervals for various bearing types running at different speeds. This figure applies only if the temperature of the bearing is less than 70°C; the replenishment time interval must be reduced by half for every 15°C temperature rise of the bearings.

The refilling intervals shown in **Fig. 6.2** are for applications where the entry of damaging foreign debris such as dust, dirt and water is limited. Therefore, when such damaging

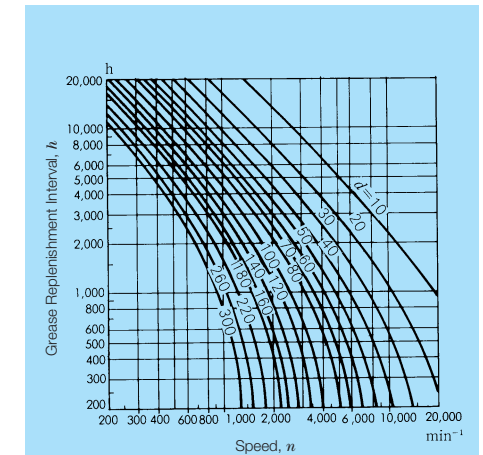


Fig. 6.2 Grease Replenishment Intervals

influences are present, it is necessary to shorten the refilling interval.

### 6.3.4 Oil Lubrication

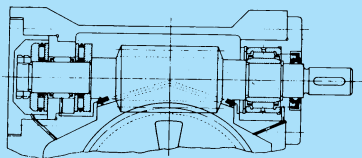
#### (1) Oil Bath Lubrication

Oil bath lubrication is a widely used method in the case of low or medium speeds. The oil level should be at the center of the lowest roller. It is desirable to provide a sight gauge so the proper oil level may be maintained.

#### (2) Splash Lubrication

With this lubricating method, oil is splashed onto the bearing by a gear or rotating disc installed near the bearing. The entry of oil into the bearing depends on the position of the bearing, bearing type, how the splash is produced, and other factors. Improper lubrication at the beginning of rotation occurs in some cases due to the insufficient supply of oil. The reduction gear with an oil reservoir and device for maintaining the oil level shown in **Fig. 6.3** provides an example of how to prevent such insufficient initial-stage lubrication.

Another effective method of splash lubrication involves an oil reservoir with a V-shaped oil groove and the positioning of the oil drain in a high location. Additionally, installing a device with a magnetic plug to protect against the penetration of wear particles generated by gears is effective.



**Fig. 6.3** Splash Lubrication

#### (3) Circulating Lubrication

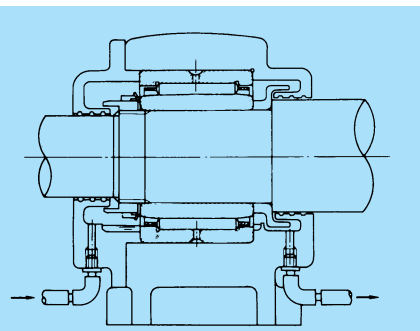
Circulating lubrication is commonly used for high-speed operation requiring bearing cooling and for bearings used at high temperatures. As shown in **Fig. 6.4**, oil is supplied by the pipe on the right side, it travels through the bearing and drains out through the pipe on the left. After being cooled in a reservoir, it returns to the bearing through a pump and filter. The oil discharge pipe should be larger than the supply pipe so an excessive amount of oil will not back up in the housing.

#### (4) Drip Feed Lubrication

This method uses an oiler from which a small amount of oil drips into the bearing. The amount of oil supplied varies depending on bearing type. For smaller bearings, the oil supply rate is generally one drop every three to eight seconds. This method can be used at relatively high speeds for normal or light loads.

#### (5) Other Oil Lubrication Methods

Other methods include jet lubrication and oil mist lubrication. For needle bearings, however, these are not commonly used because of the limitation on limiting speed and space in the vicinity of the bearing.



**Fig. 6.4** Circulating Lubrication

## 7. Bearing Seals

To ensure the longest possible life of a bearing, it may be necessary to provide seals to prevent leakage of lubricant and entry of dust, water and other harmful material like metallic particles. The seals must be free from excessive running friction and the probability of seizure. They should also be easy to assemble and disassemble. It is necessary to select a suitable seal for each application considering the lubricating method.

Contact seals are effective because of the contact they maintain with the shaft. They are made of synthetic rubber, synthetic resin, felt or other materials, depending on operating conditions and type of lubricant. Oil seals with synthetic rubber lips are the most common.

### 7.1 Oil Seals

Synthetic rubber oil seals are usually used in environments where large amounts of dust, dirt, water and other foreign matter can easily enter bearings. Oil seals are standardized in JIS B2402. Suitable oil seals for NSK drawn cup needle roller bearings are listed in the bearing tables on page B242.

When mounting a synthetic rubber oil seal, lubricant should be applied to the seal lip and shaft. When oil seals are used at high peripheral surface speed or under high internal pressure, the contact surface of the shaft must be smoothly finished and the shaft eccentricity should be 0.02 to 0.05 mm or less.

The contact surface of the shaft should be hardened to enhance its resistance to wear. Generally, hardness of the shaft surface should be higher than HRC40. However, under high-wear conditions, it should be higher than HRC55.

Permissible peripheral speeds and temperature ranges are shown in **Table 7.1**, and criteria for the relationship between shaft peripheral surface speed and the roughness of contact surfaces are shown in **Table 7.2**.

**Table 7.1** Permissible Peripheral Speeds and Temperature Ranges for Oil Seals

Seal Materials		Permissible Peripheral Speed (m/s)	Operating Temperature Range (°C) <sup>(1)</sup>
Synthetic Rubber	Nitrile Rubber	≤ 16	−25 to +100
	Acrylic Rubber	≤ 25	−15 to +130
	Silicone Rubber	≤ 32	−70 to +200
	Fluorine Rubber	≤ 32	−30 to +200
Tetrafluoroethylene Resin		≤ 15	−50 to +220

**Note** <sup>(1)</sup> The upper limit of the temperature range may be raised by about 20°C when operating at short intervals.

**Table 7.2** Shaft Peripheral Speed and Roughness of Contact Surfaces

Peripheral Speed (m/s)	Surface Roughness $R_a$
≤ 5	0.8
(5) to 10	0.4
> 10	0.2

### 7.2 Oil Grooves

Oil grooves, flingers and labyrinths function as non-contact seals. Sealing is achieved by several grooves provided on either or both the shaft and housing. Applying grooves on both surfaces is more efficient for oil lubrication. The clearance between the shaft and housing should be as small as possible. Recommended clearance values are shown in **Table 7.3**.

**Table 7.3** Clearances between Shaft and Housing for Oil-Groove Seals

Units: mm

Nominal Shaft Diameter	Radial Clearance
≤ 50	0.25 to 0.4
(50) to 200	0.5 to 1.5

The recommended groove width is approximately 3 to 5 mm, with a depth of about 4 to 5 mm.

When using only grooves for sealing, three or more of them should be used. This sealing method is frequently used to prevent leakage of



oil when the presence of dust and foreign particles is relatively low. Oil grooves are efficient for both oil and grease lubrication at low-speed operation. Filling the groove with grease of a consistency of approximately 200 is most effective.

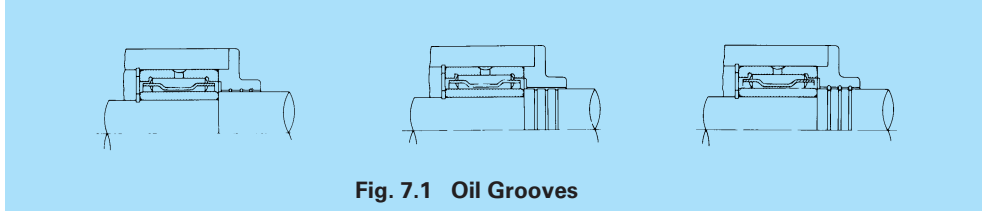


Fig. 7.1 Oil Grooves

### 7.3 Flingers (Slings)

Flingers use centrifugal force to throw off oil and dust, and at the same time act as a pump to prevent the leakage of oil and entry of dust.

As shown in Fig. 7.2, a flinger used for preventing the entry of dust is effective when combined with other bearing seals. However, due to the fact that the centrifugal force of the flinger pulls the oil inside the housing, care should be exercised during design.

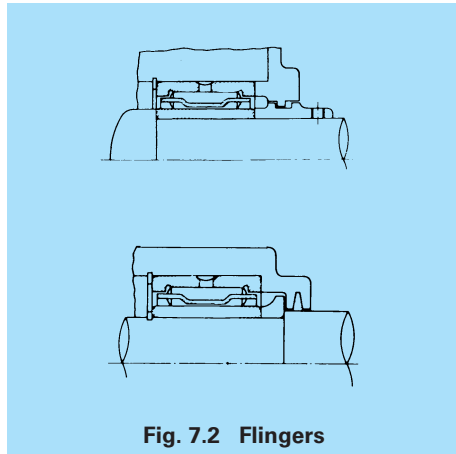


Fig. 7.2 Flingers

### 7.4 Labyrinth Seals

Among non-contact methods, the labyrinth seal is the most effective and appropriate for preventing oil leakage from a high-speed shaft. The clearance values shown in Table 7.4 for labyrinth seals are recommended. The sealing effect can be enhanced by filling the clearance with grease. Various structures for labyrinth seals exist. An example is shown in Fig. 7.3.

Table 7.4 Clearance for Labyrinth Seals

Units: mm

Nominal Shaft Diameter	Clearance	
	Radial	Axial
≤ 50	0.25 to 0.4	1 to 2
(50) to 200	0.5 to 1.5	2 to 5

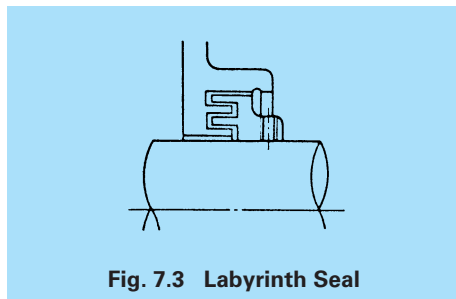


Fig. 7.3 Labyrinth Seal

## 8. Bearing Handling

### 8.1 Precautions for Proper Handling of Bearings

Rolling bearings are high-precision machine parts and must be handled accordingly. Even if high-quality bearings are used, their expected performance cannot be achieved if they are not handled properly. The main precautions to be observed are as follows:

#### (1) Keep Bearings and Surrounding Area Clean

Dust and dirt, even if invisible to the naked eye, have harmful effects on bearings. It is necessary to prevent the entry of dust and dirt by keeping the bearings and their environment as clean as possible.

#### (2) Handle Bearings Carefully

Heavy shocks during handling may cause bearings to be scratched or otherwise damaged, possibly resulting in their failure. Excessively strong impacts may cause brinelling, breaking, or cracking.

#### (3) Use Proper Tools

Always use the proper equipment when handling bearings and avoid general-purpose tools.

#### (4) Prevent Corrosion

As perspiration from hands and various other contaminants may cause corrosion, keep hands clean when handling bearings. Wear gloves if possible. Take care to prevent rusting of bearings caused by corrosive gasses.

### 8.2 Mounting

Mounting methods vary depending on bearing type and conditions. It is important to fully understand each bearing and handle it properly. In this section, general mounting methods are described. Please note that special precautions apply when mounting drawn cup needle bearings (see page B41).

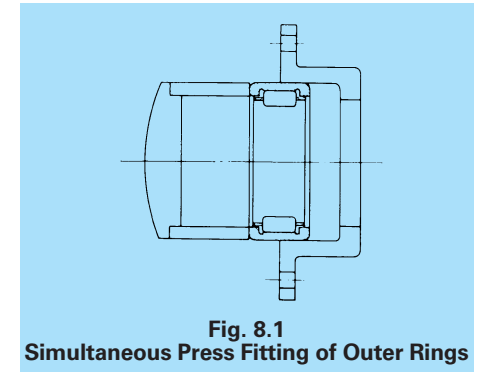


Fig. 8.1 Simultaneous Press Fitting of Outer Rings

#### (1) Press Fits

Fitting with a press is very common. The mounting dolly is placed onto a raceway ring (an inner or outer bearing ring) that is on the insertion side, then the ring is pushed up into position slowly by a press. An example for an outer ring is shown in Fig. 8.1.

#### (2) Shrink Fits

When mounting an inner ring onto a shaft, shrink fitting is widely used. The maximum heating temperature of the bearing must be no

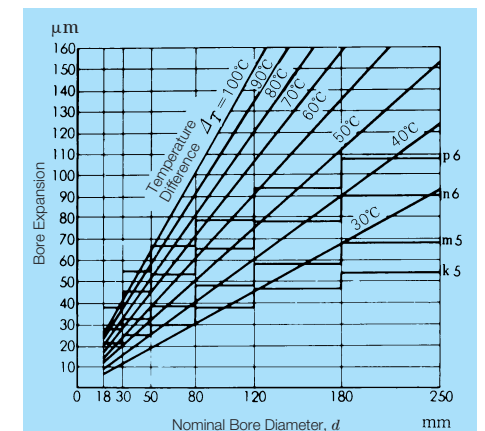


Fig. 8.2 Heat Temperature Differences and Thermal Expansion of Inner Ring

more than 120°C. When the bearing is cooled down after mounting, the inner ring contracts in the axial direction, creating a clearance between the inner ring and shoulder. To prevent this clearance from occurring, the inner ring and shoulder should be kept in tight contact with each other using a nut. The relationship between heat temperature differences, bearing dimensions and the amount of inner ring expansion is shown in Fig. 8.2.

**(3) Driving Fits**

When interference is low in bearings with small dimensions, driving fitting is sometimes used during mounting. In this method, a hammer (made of resin) is used to drive the ring in. The mounting dolly is placed on the ring's surface, and force must be applied evenly to its entire surface. However, this method is not generally recommended because it often causes bearing damage.

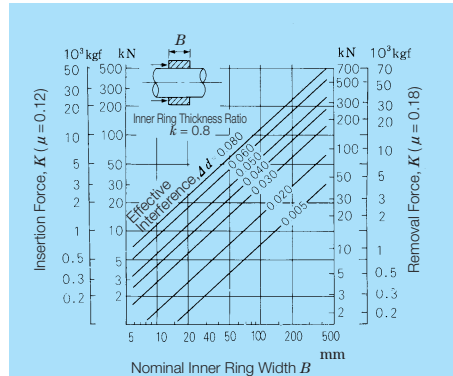
**8.3 Insertion and Removal Force**

Insertion force, which is the force to press the bearing onto a shaft or into a housing with interference, and removal force, which is the force to remove the bearing from a shaft or housing, are calculated using the following equation.

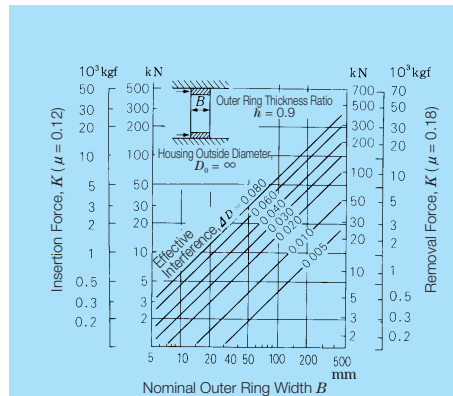
$$K = \mu p_m \pi d \text{ (or } D) \cdot B \dots \dots \dots (8.1)$$

- where,  $K$ : Insertion force or removal force (N), {kgf}
- $p_m$ : Surface pressure on the fitting surface (refer to Table 5.1) (N/mm<sup>2</sup>), {kgf/mm<sup>2</sup>}
- $d$ : Nominal bore diameter (mm)
- $D$ : Nominal outside diameter (mm)
- $B$ : Nominal inner (outer) ring width (mm)
- $\mu$ : Sliding friction coefficient of shaft and inner ring, or of housing and outer ring (from Table 8.1)

The value  $p_m$  in equation 8.1 is calculated from the value found in Table 5.1. However, in the case of an inner ring and shaft, the value  $k$



**Fig. 8.3**  
Insertion and Removal Force for Inner Ring



**Fig. 8.4**  
Insertion and Removal Force for Outer Ring

in Table 5.1 varies, depending on bearing type and dimension series, between 0.7 to 0.9. Assuming  $k = 0.8$ , the line graphs shown in Fig. 8.3 are calculated when the shaft is solid (i.e.,  $k_0 = 0$ ).

Likewise, the insertion and removal forces calculated for outer rings and the housings at  $h = 0.9$  and  $h_0 \doteq 0$  are shown in Fig. 8.4.

The actual insertion and removal force may significantly exceed calculated values due to mounting error. The values in Fig. 8.3 and 8.4

are considered only as guide values. When designing withdrawal tools, rigidity tolerances should be 5 to 6 times the values found in the figures.

**Table 8.1** Coefficient of Sliding Friction for Insertion and Removal

	$\mu$
When inner ring is pressed onto cylindrical shaft or outer ring is pressed into housing bore	0.12
When inner ring is removed from cylindrical shaft or outer ring is removed from housing bore	0.18

**8.4 Operating Inspection**

After mounting has been completed, a running test should be conducted to determine if the bearing has been properly mounted. Any sharp increase in speed to normal levels should be avoided as this could cause damage in the bearing in the event of improper mounting or heat seizure of the bearing in the event of incorrect lubrication.

During the operating inspection, it is necessary to check for the following items to determine if there are any abnormalities:

**(1) Manual Inspection**

- Sticking (dust and dirt, flaws)
- Uneven torque (improper mounting)
- Excessive torque (inadequate clearance, high seal friction)

**(2) Powered Operating Inspection**

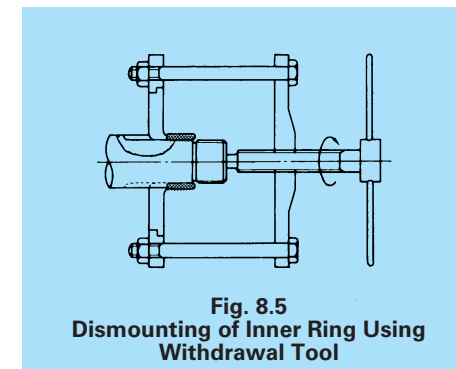
- Abnormal noise (dust and dirt, flaws, incorrect lubrication, excessive or insufficient residual clearance)
- Operating temperature saturation, temperature rise per unit hours (incorrect lubrication, improper mounting)

During the powered inspection, gradually increase speed while ensuring that no abnormalities appear at each stage. Only the powered operating inspection is necessary for large bearings.

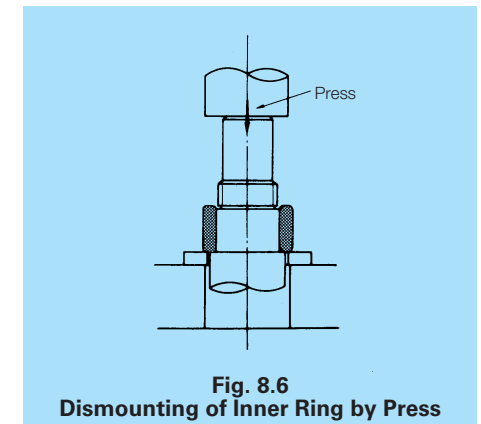
**8.5 Dismounting**

Bearings are dismantled for periodic inspections and other purposes. When the bearing is planned to be reused after dismantling or to have its condition examined, dismantling has to be carried out with extra care. When the fit is tight, dismantling is difficult. Therefore, careful consideration should be taken in designing the structure of the bearing vicinity.

When dismantling bearings, specially designed withdrawal tools (Fig. 8.5) or presses (Fig. 8.6) are to be used.



**Fig. 8.5**  
Dismounting of Inner Ring Using Withdrawal Tool



**Fig. 8.6**  
Dismounting of Inner Ring by Press

## **8.6 Cleaning**

When a dismantled bearing is being reused, the bearing should be cleaned to remove harmful foreign matter such as sand metallic particles, sludge and deteriorated lubricant. Light oil or kerosene is generally used as a cleaning agent. The cleaning procedure should be divided into a rough wash and a finishing wash, and a container with an elevated metal net should be used so that the bearing does not contact the bottom of the container.

Maintaining the cleanliness of the cleaning oil is very important. It should therefore be circulated through a filter at all times.

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<b>Metric Design (FB)</b>	
Bore Diameter 20 – 55 mm .....	B172 – B173
<b>Metric Design (FH, FG)</b>	
Bore Diameter 22.6 – 43 mm .....	B174 – B175
<b>CAM FOLLOWERS</b> .....	B176 – B189
<b>Metric Design</b>	
Outside Diameter 10 – 90 mm .....	B182 – B185
<b>Inch Design</b>	
Outside Diameter 12.700 – 152.400 mm .....	B186 – B189
<b>ROLLER FOLLOWERS</b> .....	B190 – B197
<b>Metric Design</b>	
Bore Diameter 5 – 50 mm .....	B194 – B195
<b>Inch Design</b>	
Bore Diameter 6.350 – 57.150 mm .....	B196 – B197
<b>NEEDLE ROLLERS</b> .....	B198 – B207
<b>Metric Design</b>	
Roller Diameter 1 – 5 mm .....	B200
<b>Inch Design</b>	
Roller Diameter 0.792 – 6.350 mm .....	B207
<b>SPHERICAL PLAIN BEARINGS</b> .....	B208 – B219
<b>Metric Design</b>	
Bore Diameter 12 – 160 mm .....	B214 – B217
<b>Inch Design</b>	
Bore Diameter 12.700 – 152.400 mm .....	B218 – B219
<b>NEEDLE ROLLER BEARINGS FOR UNIVERSAL JOINTS</b> .....	B220 – B227
<b>Drawn Cup Type</b>	
Inscribed Circle Diameter 10 – 21.3 mm .....	B224 – B225
<b>Solid Type</b>	
Inscribed Circle Diameter 12.170 – 32.600 mm .....	B226 – B227
<b>DRAWN CUP ROLLER CLUTCHES</b> .....	B228 – B237
<b>FC, FLC, RC</b>	
Inscribed Circle Diameter 4 – 30 mm .....	B234 – B235
<b>FCB, FCBN, RCB</b>	
Inscribed Circle Diameter 4 – 30 mm .....	B236 – B237
<b>OIL SEALS FOR NEEDLE ROLLER BEARINGS</b> .....	B238 – B242
<b>Single-Lip Synthetic Rubber Seals</b> .....	B242
<b>Double-Lip Synthetic Rubber Seals</b> .....	B242

## CAGE &amp; NEEDLE ROLLER ASSEMBLIES

	Pages
Metric Design Cage & Needle Roller Assemblies	
Inscribed Circle Diameter    4–150 mm .....	B12–B29
Inch Design Cage & Needle Roller Assemblies	
Inscribed Circle Diameter    9.525–127.000 mm .....	B30–B33
Cage & Needle Roller Assemblies for Large Ends of Connecting Rods	
Inscribed Circle Diameter    12–30 mm .....	B34
Cage & Needle Roller Assemblies for Small Ends of Connecting Rods	
Inscribed Circle Diameter    9–19 mm .....	B35

NSK cage & Needle roller assemblies consist of a complement of needle rollers held in place by a cage. Their unitized design makes for easy handling and installation. With no inner or outer ring, the low cross-section provides maximum load-carrying capability within the smallest envelope. Properly lubricated, they can operate at high speeds thanks to the unique cage, which guides the rollers precisely. The controlled contour rollers in cage & Needle roller assemblies have an optimum profile which reduces end stresses, allows operation under moderate misalignment and prolongs bearing life.

## DESIGN AND TYPES

The most common cage used in cage & Needle roller assemblies is the M-type. M-type cages are either pressed from steel plate or machined. These cages undergo surface hardening after processing to attain high wear resistance and rigidity. The cages facilitate optimum lubrication conditions because lubricant can be easily replenished. Other cages include those made by precision pressing, welded cages and polyamide molded cages. Welded cages, which are produced by welding pressed steel, are especially suited for mass production. Applying its considerable experience and knowledge, NSK supplies cage & Needle roller assemblies of the highest quality.

Codes for the various types of cage & Needle roller assemblies are shown in **Table 1**. There are many types of cage & Needle roller assemblies other than those in **Table 1**, including split cages. Cage & Needle roller assemblies for engine connecting rods are included on page B9 as one of a special series.

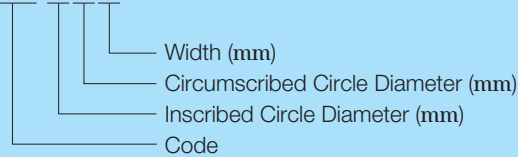


**Table 1 Cage & Needle Roller Assembly Codes**

Cage Type		Code	
		Metric	Inch
Single Row	M Cage	WFJ, FWF	WJ
	FBN Cage	FBN	—
	Welded Cage	FWJC, FWJW	WJC
	Polymide Cage	FBNP	—
Double Row	M Cage	FWF ... W, FDJ	DJ
	FBN Cage	FBN ... W	—
	Welded Cage	FDJC	DJC
	Polymide Cage	FBNP ... W	—

An example of a bearing number is as follows:

**(Example) FWD-202620**



For inch bearings, each dimension is expressed with two digit whole numbers in units of 1/16 of an inch following the type code.

**ACCURACY STANDARDS**

NSK cage & Needle roller assemblies use rollers classified as JIS third class or higher. Roller accuracy is shown in **Table 2**.

**Table 2 Accuracy of Needle Rollers**

Units:  $\mu\text{m}$

Class	Tolerance in Average Value of Diameter		Diameter Variation in a Single Radial Plane, <sup>(1)</sup> $VD_{WP}$ max	Deviation from Circular Form, <sup>(1)</sup> $\Delta R$ max	Diameter Variation within Gauge Lot, <sup>(1)</sup> $VD_{WL}$ max	Deviation in length, <sup>(2)</sup> $\Delta L_{WS}$
	high	low				
2	0	-5	1	1	2	h13
3	0	-5	1.5	1.5	3	h13
5	0	-5	2	2.5	5	h13

**Note** <sup>(1)</sup> Applies at the center of roller's length.

<sup>(2)</sup> Depends on  $L_w$  classification. h13 is shown in **Table 5**, page B201.

**Remarks** Deviation between the actual measured diameter at any point over the entire length of roller and the actual maximum diameter at the center of the entire length must not exceed the following values:

- Class 2: 0.5  $\mu\text{m}$
- Class 3: 0.8  $\mu\text{m}$
- Class 5: 1  $\mu\text{m}$

**APPLICATION**

**Mounting**

(1) With cage & Needle roller assemblies, the shaft and housing are generally used as raceway rings. It is important to satisfy the finish accuracy and hardness requirements in **Table 3**.

**Table 3 Accuracy and Hardness for Shaft and Housing**

Item	Shaft	Housing
Out-of-Roundness Tolerance	IT3 2	IT3 2
Cylindricity Tolerance	IT3 2	IT3 2
Roughness, Ra	0.4	0.8
Hardness	HRC58 to 64 Appropriate depth of hardened layer required	HRC58 to 64 Appropriate depth of hardened layer required

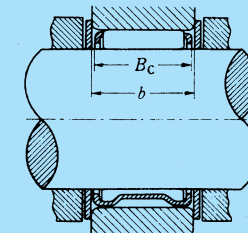
**Remarks** For details, please refer to Section 5.2 on page A34 and Section 5.3 on page A35.

(2) Guide width for cage & Needle roller assemblies

The tolerances for the guide width,  $b$ , are based on cage width,  $B_C$ , and shown in **Table 4** (see **Fig. 1**).

**Table 4 Tolerances for Guide Width,  $b$**

Type	Tolerance for $b$
Metric	$B_C^{+0.2}$
Inch	$B_C^{+0.2}$



**Fig. 1**

(3) Fillet Radius

The fillet radius of the shaft and housing shoulder in contact with the cage end surface should not interfere with the cage itself.

### Fitting Tolerances for Shafts and Housing Bores

Fitting tolerances for shafts and housing bores under various operating conditions are shown in **Table 5**.

**Table 5 Fitting Tolerances for Shafts and Housing Bores**

Operating Conditions		High Accuracy, Oscillating Motion	Normal	High Temperature, Large Shaft Deflection, Mounting Error
Fitting Tolerance for Housing Bore		G6	G6	G6
Fitting Tolerance for Shaft	$F_w \leq 50\text{mm}$	j5	h5	f6
	$F_w > 50\text{mm}$	h5	g5	

### Shaft Inclination

Permissible shaft inclinations from elastic deflection by external force and mounting error are shown in **Table 6**. When shaft inclination exceeds that in this table, please consult NSK because it is necessary to change the amount of the rollers' crowning and increase the internal clearance.

**Table 6 Shaft Inclination**

Cage Width (mm)	Permissible Inclination (mm/mm) max
$\leq 25$	0.0015
(25) to 50	0.0010
$> 50$	0.0005

## Cage & Needle Roller Assemblies for Connecting Rods

Cage & Needle roller assemblies for connecting rods used in small general-purpose engines such as those in compact cars, motorcycles, outboard marine motors, snow-mobles and chain-saws operate in harsh conditions characterized by shock loads, complex motion, high temperatures, and lubrication difficulties. Cage & Needle roller assemblies FWF ... E, FBN ... E are specially designed for such conditions. Cage & Needle roller assemblies for connecting rods contain a highly rigid and wear-resistant lightweight cage and high-accuracy rollers with special crowning.

### TYPES

#### Cage & Needle Roller Assemblies for the Large Ends of Connecting Rods FWF ... E

FWF ... E Cage & Needle roller assemblies for large ends of connecting rods are lightweight and highly rigid. Their outside surface is accurately finished to maintain proper guide clearance during operation. Special steel that is hardened to the proper depth by carbonitriding is used as material for the cages. Depending on operating conditions, wear resistance is enhanced by surface treatment with non-ferrous metal.

For integrated one-piece crankshafts, split cage & Needle roller assemblies are also manufactured.

#### Cage & Needle Roller Assemblies for the Small Ends of Connecting Rods FBN ... E

Owing to their high static load rating, cage & Needle roller assemblies for small ends of connecting rods contain many long rollers with diameters of 1.5 to 2.5 mm, lowering the contact pressure within the load zone. Depending on the structure of the engine, a bore surface-guided or outside diameter-guided cage is used.



## APPLICATIONS

### Specifications for Connecting Rods, Crank Pins and Gudgeon Pins

The small and large end bores of the connecting rod, which function as the raceway surface of the cage & Needle roller assemblies, and the outside diameter of the crank pin and gudgeon pin must have the following specifications in order to obtain the best performance, even under harsh operating conditions, from cage & Needle roller assemblies for connecting rods.

#### (1) Raceway Surface Roughness

The roughness of the raceway surface of the crank pin and gudgeon pin, which can lead to premature wear under severe operating conditions, should be approximately  $0.1\mu\text{mR}_{\text{max}}$ . Roughness for the large end bore and small end bore of the connecting rod should be  $0.25\mu\text{mRa}$  or less.

#### (2) Raceway Surface Hardness and Effective Hardened Layer Depth

The surface hardness of the raceway should be HRC60 to 64. The effective hardened layer depth (depth to HV550) varies depending on load conditions, but should range from 0.6 to 1.2 mm.

#### (3) Raceway Accuracy

Requirements for out-of-roundness and cylindricity of the raceway are listed in **Table 1**.

**Table 1 Out-of-Roundness and Cylindricity of Raceway**

Units:  $\mu\text{m}$

Diameter Classification (mm)		Large/Small End Bore		Crank Pin/Gudgeon Pin	
over	incl	Out-of-roundness max	Cylindricity max	Out-of-roundness max	Cylindricity max
—	18	5	3	4	2
18	30	6	4	4	2
30	40	8	4	5	3

#### (4) Parallelism for Large and Small End Bores of Connecting Rods

Improper parallelism between the large end bore and small end bore of the connecting rod decreases engine performance. The two bores therefore have to be finished with a high degree of accuracy. It is recommended that parallelism is less than or equal to 0.04 mm for each 100 mm for normal and low speeds, and less than or equal to 0.02 mm for each 100 mm for high speeds.

#### (5) Abutment Tolerance for Mounting

Radial internal clearance in cage & Needle roller assemblies for connecting rod large and small ends should be determined by engine type, characteristics, and operating conditions. In general, h5 for the piston diameter, G6 for the small end bore, g5 or f5 for the crank pin diameter, and G6 for the large end bore should be applied. When the radial internal clearance has to be strictly limited, it is recommended to use the values in **Table 2**. As to the large end, the upper limit of the internal clearance should be the target value under high-speed rotation.

**Table 2 Recommended Radial Internal Clearance**

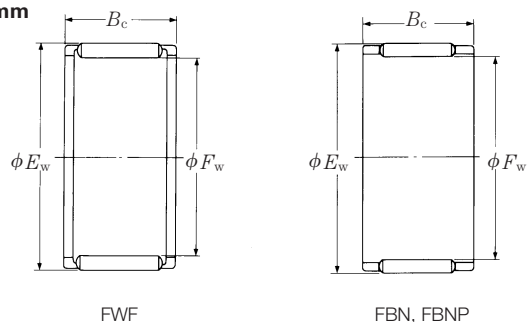
Units:  $\mu\text{m}$

Shaft Diameter Classification (mm)		Large End		Small End	
over	incl	min	max	min	max
6	10	—	—	5	15
10	18	12	24	6	18
18	30	14	28	7	20
30	—	18	34	—	—

FWF

FBN • FBNP

Inscribed Circle Diameter 4 – 12 mm



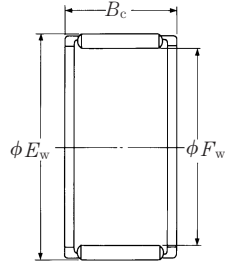
$F_w$	Boundary Dimensions (mm)		Basic Load Ratings				Limiting Speeds (min <sup>-1</sup> ) Oil
	$E_w$	$B_c$ <small>-0.2 -0.55</small>	$C_r$ (N)	$C_{or}$ (N)	$C_r$ (kgf)	$C_{or}$ (kgf)	
<b>4</b>	7	7	1 710	1 220	175	124	120 000
<b>5</b>	8	8	2 330	1 860	237	189	95 000
<b>6</b>	9	8	2 200	1 780	224	182	75 000
	9	10	2 980	2 630	305	268	75 000
	10	13	4 300	3 600	435	365	80 000
<b>7</b>	10	8	2 840	2 560	290	261	67 000
	10	10	3 650	3 550	375	360	67 000
<b>8</b>	11	8	3 050	2 900	310	296	56 000
	11	10	3 500	3 450	360	355	56 000
	11	13	4 750	5 150	485	525	56 000
<b>9</b>	12	10	3 750	3 850	380	395	50 000
	12	13	5 100	5 750	520	585	50 000
<b>10</b>	13	8	3 450	3 600	355	365	45 000
	13	10	3 950	4 300	405	435	45 000
	13	11	4 450	5 000	455	505	45 000
	13	13	5 400	6 350	550	650	45 000
	14	8	3 750	3 300	385	340	45 000
	14	10	5 350	5 300	545	540	45 000
<b>11</b>	14	13	6 500	6 750	660	690	45 000
	16	12	7 700	6 650	785	680	48 000
	14	10	3 950	4 350	400	440	40 000
<b>12</b>	15	9	4 350	5 100	445	520	36 000
	15	10	4 350	5 100	445	520	36 000
	15	12	5 400	6 750	555	690	36 000
	15	13	5 950	7 600	605	775	36 000
	16	10	5 700	5 950	580	610	38 000
	16	13	7 350	8 350	750	850	38 000
	17	13	8 250	8 350	840	855	38 000
	18	12	9 150	8 650	935	885	38 000

Bearing Numbers	Mass (g) approx
<b>* FBNP-477</b>	0.5
<b>* FBNP-588</b>	1.0
<b>* FBNP-698</b>	1.2
<b>* FBNP-6910</b>	1.5
<b>* FBNP-61013</b>	2.8
<b>* FBNP-7108</b>	1.3
<b>* FBNP-71010</b>	1.6
<b>* FBNP-8118</b>	1.4
<b>* FBNP-81110</b>	1.8
<b>* FBNP-81113</b>	2.6
<b>* FBNP-91210</b>	2.0
<b>* FBNP-91213</b>	2.6
<b>FBN-10138</b>	2.0
<b>FBN-101310</b>	2.2
<b>FBN-101311</b>	2.4
<b>FBN-101313</b>	2.9
<b>FBN-10148</b>	2.5
<b>FWF-101410</b>	3.1
<b>FWF-101413</b>	4.0
<b>FWF-101612</b>	6.0
<b>FBN-111410</b>	2.6
<b>FBN-12159</b>	2.4
<b>FBN-121510</b>	2.6
<b>FBN-121512</b>	3.1
<b>FBN-121513</b>	3.4
<b>FWF-121610</b>	3.6
<b>FWF-121613</b>	4.6
<b>FWF-121713</b>	6.0
<b>FWF-121812</b>	6.9

\* These bearings have polyamide cages. The maximum permissible operating temperature for these bearings is 100°C for continued operation and 120°C for short periods.

FWF • FWJ

Inscribed Circle Diameter 14 — 17 mm



FWF, FWJ

$F_w$	Boundary Dimensions (mm)		Basic Load Ratings				Limiting Speeds (min <sup>-1</sup> )
	$E_w$	$B_c$ <small>-0.2 -0.35</small>	$C_r$ (N)	$C_{or}$ (N)	$C_r$ (kgf)	$C_{or}$ (kgf)	
<b>14</b>	18	10	6 750	7 750	690	790	32 000
	18	11	6 650	7 600	675	775	32 000
	18	13	8 050	9 750	820	995	32 000
	18	17	10 700	14 100	1 090	1 430	32 000
	18	20	12 100	16 400	1 230	1 670	32 000
	20	12	9 850	9 800	1 010	1 000	32 000
<b>15</b>	20	17	13 400	14 600	1 370	1 490	32 000
	19	10	7 050	8 400	720	855	28 000
	19	13	8 400	10 500	860	1 070	28 000
	19	17	11 200	15 200	1 140	1 550	28 000
	20	13	9 950	11 300	1 010	1 150	30 000
	21	15	12 600	13 600	1 280	1 380	30 000
<b>16</b>	21	17	13 400	14 800	1 370	1 510	30 000
	21	21	16 300	18 900	1 660	1 930	30 000
	20	10	7 350	9 000	750	920	26 000
	20	13	8 800	11 300	895	1 150	26 000
	20	17	11 700	16 300	1 190	1 660	26 000
	21	13	10 500	12 300	1 070	1 250	28 000
<b>17</b>	21	17	13 000	16 200	1 330	1 660	28 000
	21	26	20 000	28 200	2 040	2 880	28 000
	21	27	20 800	29 600	2 120	3 000	28 000
	22	12	10 500	10 900	1 070	1 120	28 000
	22	13	10 900	11 500	1 120	1 180	28 000
	22	17	14 700	16 900	1 500	1 720	28 000
<b>17</b>	22	20	17 000	20 300	1 730	2 070	28 000
	22	22	18 700	22 900	1 900	2 340	28 000
	22	24	20 300	25 600	2 070	2 610	28 000
	24	20	20 800	22 200	2 120	2 270	30 000
	21	10	7 650	9 650	780	985	26 000
	21	13	10 200	14 000	1 040	1 420	26 000
<b>17</b>	21	15	10 800	15 000	1 100	1 530	26 000
	21	16	11 500	16 300	1 170	1 670	26 000
	21	17	11 500	16 300	1 170	1 670	26 000
	22	20	15 400	20 400	1 570	2 080	26 000
	23	17	15 100	17 800	1 540	1 810	26 000

Bearing Numbers	Mass (g)
	approx
<b>FWF-141810</b>	4.1
<b>FWF-141811</b>	4.5
<b>FWF-141813</b>	5.3
<b>FWF-141817</b>	6.9
<b>FWF-141820</b>	10
<b>FWF-142012</b>	7.8
<b>FWF-142017</b>	11
<b>FWF-151910</b>	4.3
<b>FWF-151913</b>	5.6
<b>FWF-151917</b>	7.4
<b>FWF-152013</b>	7.2
<b>FWF-152115</b>	10
<b>FWF-152117</b>	12
<b>FWF-152121A</b>	14
<b>FWF-162010</b>	4.6
<b>FWF-162013</b>	6.0
<b>FWF-162017</b>	7.8
<b>FWF-162113</b>	7.7
<b>FWF-162117</b>	10
<b>FWF-162126</b>	15
<b>FWF-162127</b>	16
<b>FWF-162212</b>	8.7
<b>FWF-162213</b>	9.4
<b>FWF-162217</b>	12
<b>FWF-162220</b>	14
<b>FWF-162222</b>	16
<b>FWF-162224</b>	17
<b>FWF-162420</b>	20
<b>FWF-172110</b>	4.8
<b>FWJ-172113</b>	6.3
<b>FWF-172115</b>	7.5
<b>FWF-172116</b>	8.0
<b>FWF-172117</b>	8.2
<b>FWF-172220</b>	16
<b>FWF-172317</b>	14

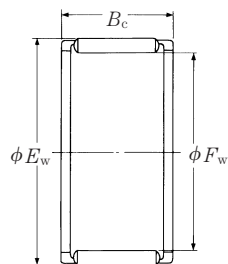
FWF • FWJ

FWF...W

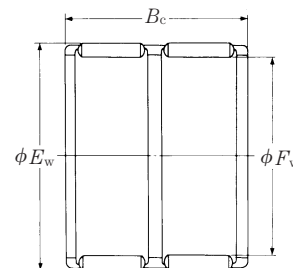
FBN...W

Inscribed Circle

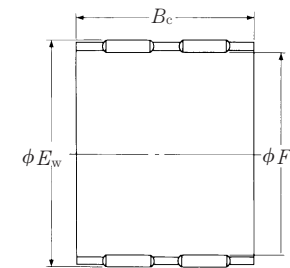
Diameter 17.57 — 21 mm



FWF, FWJ



FWF...W



FBN...W

Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
F <sub>w</sub>	E <sub>w</sub>	B <sub>c</sub> <small>-0.2 -0.35</small>	C <sub>r</sub>	C <sub>or</sub>	{kgf}		
<b>17.57</b>	22.6	21	16 600	22 700	1 700	2 320	24 000
	23.6	32	29 300	42 000	2 990	4 300	26 000
<b>18</b>	22	10	7 900	10 300	805	1 050	24 000
	22	13	9 450	12 900	965	1 310	24 000
	22	17	12 600	18 600	1 280	1 900	24 000
	22	28	16 100	25 400	1 640	2 590	24 000
	23	20	16 600	22 900	1 690	2 340	24 000
	24	12	11 700	13 000	1 190	1 320	24 000
	24	13	12 800	14 600	1 300	1 490	24 000
	24	17	17 400	21 600	1 770	2 210	24 000
	24	20	18 900	24 100	1 930	2 460	24 000
	25	14	14 200	15 200	1 450	1 550	24 000
<b>19</b>	23	13	9 900	13 900	1 010	1 420	22 000
	23	17	12 300	18 500	1 260	1 880	22 000
	24	28	23 800	37 000	2 420	3 750	22 000
	31	24	31 500	31 500	3 200	3 200	26 000
<b>19.1</b>	31.1	24	31 000	30 500	3 150	3 150	24 000
<b>20</b>	24	10	8 000	10 700	815	1 090	20 000
	24	13	9 700	13 700	990	1 400	20 000
	24	17	12 400	18 800	1 260	1 910	20 000
	25	40	30 000	50 500	3 050	5 150	22 000
	26	12	12 200	14 100	1 250	1 440	22 000
	26	13	13 100	15 500	1 340	1 580	22 000
	26	16	16 600	21 000	1 700	2 140	22 000
	26	17	18 000	23 200	1 830	2 370	22 000
	26	20	19 200	25 200	1 960	2 570	22 000
	26	24	23 200	32 000	2 360	3 250	22 000
<b>21</b>	28	20	19 800	21 700	2 020	2 210	22 000
	25	13	10 500	15 500	1 070	1 580	20 000
	25	17	13 100	20 600	1 340	2 100	20 000

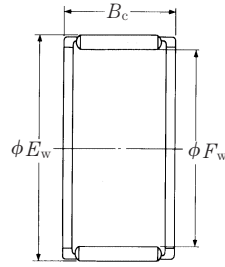
Bearing Numbers	Mass (g)
	approx
<b>FWF-172221Z</b>	13
<b>FWJ-172332Z</b>	25
<b>FWF-182210</b>	5.1
<b>FWF-182213</b>	6.6
<b>FWF-182217</b>	8.7
<b>FBN-182228W</b>	16
<b>FWF-182320</b>	13
<b>FWF-182412</b>	9.6
<b>FWF-182413</b>	10
<b>FWJ-182417</b>	14
<b>FWF-182420</b>	16
<b>FWF-182514</b>	13
<b>FWF-182517</b>	19
<b>FWF-182522</b>	21
<b>FWF-192313</b>	7.0
<b>FWF-192317</b>	9.1
<b>FWJ-192428</b>	19
<b>FWF-193124</b>	45
<b>FWJ-193124Z</b>	46
<b>FWF-202410</b>	5.6
<b>FWF-202413</b>	7.3
<b>FWF-202417</b>	9.5
<b>FWF-202540W</b>	29
<b>FWF-202612</b>	10
<b>FWF-202613</b>	11
<b>FWF-202616</b>	14
<b>FWJ-202617</b>	15
<b>FWF-202620</b>	18
<b>FWF-202624</b>	21
<b>FWF-202820</b>	28
<b>FWF-212513</b>	7.6
<b>FWF-212517</b>	10

FWF • FWJ

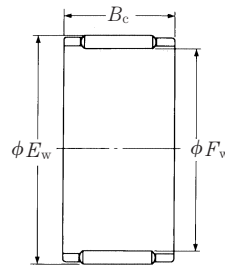
FBN

FBN···W

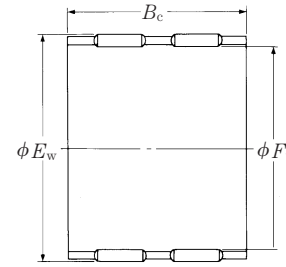
Inscribed Circle  
Diameter 22 — 26 mm



FWF, FWJ



FBN



FBN···W

Boundary Dimensions (mm)			Basic Load Ratings (N) {kgf}				Limiting Speeds (min <sup>-1</sup> )
<i>F<sub>w</sub></i>	<i>E<sub>w</sub></i>	<i>B<sub>c</sub></i> <small>-0.2 -0.35</small>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	
<b>22</b>	26	10	8 600	12 200	880	1 240	19 000
	26	11	8 600	12 200	880	1 240	19 000
	26	13	10 300	15 300	1 050	1 560	19 000
	26	17	13 000	20 700	1 330	2 110	19 000
	27	20	18 000	27 000	1 840	2 760	20 000
	28	13	13 700	16 700	1 390	1 700	20 000
	28	17	17 300	22 700	1 760	2 310	20 000
	28	23	23 600	34 000	2 410	3 450	20 000
	29	16	17 100	20 200	1 750	2 060	20 000
	30	14	17 400	19 000	1 770	1 930	20 000
<b>23</b>	28	24	22 400	36 000	2 280	3 700	19 000
<b>24</b>	28	13	10 500	16 100	1 070	1 650	17 000
	28	17	14 600	24 700	1 490	2 510	17 000
	28	25	15 900	27 400	1 620	2 800	17 000
	29	13	10 700	14 100	1 090	1 430	18 000
	30	17	17 900	24 300	1 830	2 480	18 000
	<b>25</b>	29	10	9 350	14 100	950	1 440
29		13	11 300	18 000	1 150	1 830	17 000
29		17	14 800	25 500	1 510	2 600	17 000
30		13	13 500	19 500	1 380	1 980	17 000
30		17	17 200	26 400	1 750	2 690	17 000
30		20	18 800	29 700	1 920	3 050	17 000
30		25	23 600	39 500	2 410	4 050	17 000
31		13	15 000	19 500	1 520	1 990	17 000
31		17	19 200	26 800	1 950	2 740	17 000
31		20	22 100	32 000	2 250	3 300	17 000
<b>26</b>	31	24	26 500	40 500	2 700	4 150	17 000
	32	16	18 700	23 500	1 910	2 390	17 000
	32	24	28 300	40 000	2 880	4 050	17 000
	33	20	28 400	37 000	2 900	3 750	18 000
	33	24	33 000	45 000	3 400	4 600	18 000
	30	13	10 400	16 200	1 060	1 660	16 000
	30	17	14 400	24 900	1 470	2 540	16 000
	30	24	17 900	32 500	1 820	3 350	16 000

Bearing Numbers	Mass (g)
	approx
<b>FWF-222610</b>	6.1
<b>FWF-222611</b>	7.2
<b>FWF-222613</b>	7.9
<b>FWF-222617</b>	10
<b>FWF-222720</b>	16
<b>FWF-222813</b>	12
<b>FWF-222817</b>	16
<b>FWF-222823</b>	22
<b>FWF-222916</b>	18
<b>FWF-223014</b>	24
<b>FWF-232824</b>	20
<b>FWF-242813</b>	8.6
<b>FWF-242817</b>	11
<b>FBN-242825W</b>	19
<b>FBN-242913</b>	11
<b>FWF-243017</b>	14
<b>FWF-252910</b>	6.9
<b>FWF-252913</b>	8.9
<b>FWF-252917</b>	12
<b>FWF-253013</b>	11
<b>FWF-253017</b>	14
<b>FWF-253020</b>	15
<b>FWF-253025</b>	21
<b>FWF-253113</b>	17
<b>FWF-253117</b>	18
<b>FWF-253120</b>	21
<b>FWF-253124</b>	26
<b>FWF-253216</b>	20
<b>FWF-253224</b>	30
<b>FWJ-253320</b>	30
<b>FWJ-253324</b>	36
<b>FWF-263013</b>	9.3
<b>FWF-263017</b>	12
<b>FBN-263024</b>	20

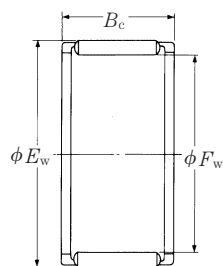
FWF • FWJ

FWF...W

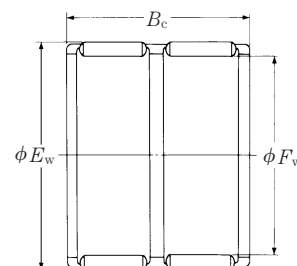
FBN...W

Inscribed Circle

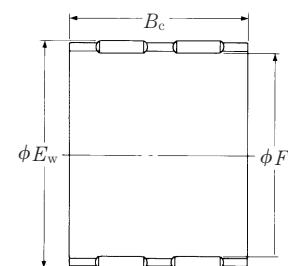
Diameter 28 — 34 mm



FWF, FWJ



FWF...W



FBN...W

Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
<i>F<sub>w</sub></i>	<i>E<sub>w</sub></i>	<i>B<sub>c</sub></i> -0.2 -0.55	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	{kgf}		
<b>28</b>	33	13	13 700	20 400	1 400	2 080	15 000
	33	17	17 100	27 100	1 740	2 760	15 000
	33	20	21 900	37 500	2 240	3 800	15 000
	33	26	27 100	49 000	2 760	5 000	15 000
	33	27	28 100	51 500	2 860	5 250	15 000
	34	17	19 900	29 100	2 020	2 970	15 000
	35	20	25 200	35 500	2 570	3 650	15 000
	36	20	26 200	34 000	2 670	3 450	16 000
<b>29</b>	34	17	17 500	28 400	1 790	2 900	14 000
	34	24	25 400	46 000	2 590	4 650	14 000
	34	27	26 600	48 500	2 710	4 950	14 000
<b>30</b>	35	13	14 000	21 600	1 430	2 200	14 000
	35	17	18 700	31 500	1 910	3 200	14 000
	35	20	21 000	36 000	2 140	3 700	14 000
	35	27	28 700	54 000	2 920	5 500	14 000
	36	14	18 400	26 900	1 870	2 750	14 000
	36	20	24 300	38 500	2 480	3 950	14 000
	36	26	29 600	49 500	3 000	5 050	14 000
	37	16	22 200	31 000	2 270	3 150	14 000
	37	20	26 000	38 000	2 650	3 850	14 000
	38	18	25 500	34 000	2 600	3 450	14 000
<b>32</b>	36	29	22 300	46 500	2 270	4 750	13 000
	37	13	15 100	24 400	1 540	2 480	13 000
	37	17	18 500	31 500	1 880	3 200	13 000
	37	23	24 300	44 500	2 480	4 550	13 000
	37	27	31 500	63 000	3 250	6 400	13 000
	37	28	25 200	47 000	2 570	4 800	13 000
	38	20	24 900	40 500	2 540	4 150	13 000
	38	26	33 000	59 000	3 400	6 000	13 000
	39	16	22 900	33 000	2 330	3 350	13 000
	39	20	27 300	41 000	2 780	4 200	13 000
	40	20	28 400	39 500	2 890	4 000	13 000
	<b>34</b>	39	23	25 100	47 500	2 560	4 850

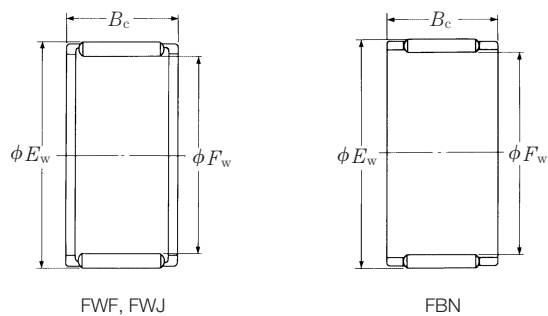
Bearing Numbers	Mass (g)
	approx
<b>FWF-283313</b>	13
<b>FWF-283317</b>	16
<b>FWJ-283320</b>	20
<b>FWF-283326</b>	25
<b>FWF-283327</b>	26
<b>FWF-283417</b>	20
<b>FWF-283520</b>	22
<b>FWF-283620</b>	33
<b>FWF-293417</b>	17
<b>FWF-293424</b>	24
<b>FWF-293427</b>	27
<b>FWF-303513</b>	14
<b>FWF-303517A</b>	18
<b>FWF-303520</b>	21
<b>FWF-303527</b>	28
<b>FWF-303614</b>	18
<b>FWF-303620</b>	25
<b>FWF-303626</b>	33
<b>FWF-303716</b>	24
<b>FWF-303720</b>	30
<b>FWF-303818</b>	32
<b>FWF-303820</b>	35
<b>FWF-303827</b>	47
<b>FWF-304025</b>	68
<b>FBN-323629WA</b>	32
<b>FWF-323713</b>	14
<b>FWJ-323717</b>	19
<b>FWJ-323723</b>	25
<b>FWJ-323727</b>	30
<b>FWF-323728W</b>	31
<b>FWF-323820</b>	27
<b>FWF-323826</b>	35
<b>FWJ-323916</b>	25
<b>FWF-323920</b>	32
<b>FWF-324020</b>	37
<b>FWJ-343923</b>	27

FWF • FWJ

FBN

Inscribed Circle

Diameter 35 — 38.1 mm



$F_w$	Boundary Dimensions (mm)		Basic Load Ratings				Limiting Speeds (min <sup>-1</sup> )
	$E_w$	$B_c$ <small>-0.2 -0.35</small>	$C_r$ (N)	$C_{or}$ (N)	$C_r$ (kgf)	$C_{or}$ (kgf)	
<b>35</b>	40	13	14 900	24 600	1 520	2 500	12 000
	40	17	20 500	37 000	2 090	3 750	12 000
	40	20	26 400	51 000	2 690	5 200	12 000
	40	25	27 200	53 000	2 770	5 400	12 000
	40	26	27 200	53 000	2 770	5 400	12 000
	40	27	31 500	64 000	3 200	6 500	12 000
	40	30	34 000	71 500	3 500	7 300	12 000
	40	32.7	30 500	61 000	3 100	6 250	12 000
	42	16	22 700	33 500	2 310	3 400	12 000
	42	18	25 900	39 500	2 640	4 000	12 000
	42	20	30 000	47 500	3 050	4 850	12 000
	42	30	43 000	75 500	4 350	7 700	12 000
<b>36</b>	44	18	29 600	39 500	3 000	4 050	12 000
	41	26	30 000	61 000	3 050	6 250	11 000
	41	30.5	32 000	66 000	3 250	6 700	11 000
	48	22.5	45 500	57 500	4 650	5 900	12 000
<b>37</b>	48	25	48 500	62 500	4 950	6 350	12 000
	42	13	16 500	28 400	1 680	2 900	11 000
	42	14.5	15 400	26 000	1 570	2 650	11 000
	42	17	20 300	37 000	2 070	3 800	11 000
	42	27	31 500	66 000	3 250	6 700	11 000
	42	30	35 500	77 000	3 650	7 850	11 000
<b>38</b>	44	18	26 500	41 500	2 700	4 200	11 000
	43	13	16 400	28 500	1 670	2 900	11 000
	43	17	20 400	38 000	2 080	3 850	11 000
	43	27	32 500	68 500	3 300	7 000	11 000
	44	27	39 000	76 500	4 000	7 800	11 000
	46	20	31 500	47 000	3 200	4 800	11 000
<b>38.1</b>	46	32	47 500	80 500	4 850	8 200	11 000
	50.8	24.7	50 500	64 000	5 150	6 500	11 000

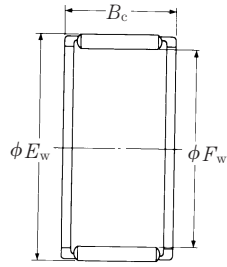
Bearing Numbers	Mass (g)
	approx
<b>FWF-354013</b>	16
<b>FWF-354017</b>	20
<b>FWJ-354020</b>	26
<b>FBN-354025</b>	30
<b>FBN-354026</b>	31
<b>FWF-354027</b>	32
<b>FWF-354030</b>	34
<b>FBN-354032Z</b>	40
<b>FWF-354216</b>	28
<b>FWF-354218</b>	31
<b>FWJ-354220</b>	34
<b>FWF-354230</b>	54
<b>FWF-354418</b>	41
<b>FWF-364126</b>	31
<b>FWJ-364130Z</b>	37
<b>FWF-364822Z</b>	72
<b>FWF-364825</b>	80
<b>FWF-374218</b>	16
<b>FWJ-374214ZA</b>	15
<b>FWJ-374217</b>	21
<b>FWJ-374227</b>	34
<b>FWF-374230</b>	43
<b>FWF-374418</b>	32
<b>FWF-384313</b>	17
<b>FWF-384317</b>	22
<b>FWF-384327</b>	35
<b>FWJ-384427</b>	42
<b>FWF-384620</b>	43
<b>FWF-384632</b>	75
<b>FWJ-385024Z</b>	93

FWF • FWJ

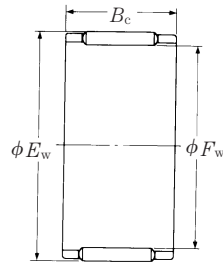
FWF...W

FBN

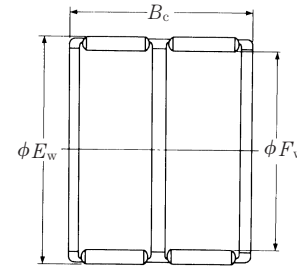
Inscribed Circle  
Diameter 40 — 52 mm



FWF, FWJ



FBN



FWF...W

Boundary Dimensions (mm)			Basic Load Ratings				Limiting Speeds (min <sup>-1</sup> )
F <sub>w</sub>	E <sub>w</sub>	B <sub>c</sub> -0.035	(N)		(kgf)		
			C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>	Oil
40	45	13	15 700	27 500	1 610	2 800	10 000
	45	17	21 000	40 000	2 150	4 050	10 000
	45	27	32 000	68 000	3 250	6 900	10 000
	45	30	35 000	77 000	3 600	7 850	10 000
	46	30	35 000	67 000	3 550	6 800	10 000
	48	20	32 500	49 500	3 300	5 050	10 000
	48	25	40 500	66 500	4 150	6 800	10 000
	48	34	53 500	95 000	5 450	9 700	10 000
42	47	17	19 600	37 000	2 000	3 750	10 000
	47	27	30 500	65 000	3 100	6 600	10 000
	50	20	33 000	52 500	3 400	5 350	10 000
43	48	17	22 800	45 500	2 330	4 650	9 500
	48	27	33 500	75 000	3 450	7 650	9 500
	49	31	44 000	92 000	4 450	9 400	9 500
45	50	17	21 600	43 000	2 200	4 350	9 000
	50	27	34 000	77 500	3 500	7 900	9 000
	51	35	46 000	99 500	4 700	10 100	9 000
	53	20	34 000	55 000	3 450	5 600	9 500
	53	25	44 000	77 000	4 500	7 850	9 500
46	52	37	43 500	94 000	4 450	9 600	9 000
47	52	17	23 400	48 500	2 390	4 900	8 500
	52	27	34 500	79 500	3 500	8 150	8 500
	52	30	36 500	86 000	3 750	8 750	8 500
	55	28	51 500	96 000	5 250	9 800	9 000
48	53	23.5	30 000	67 000	3 050	6 850	8 500
	54	20	29 800	58 500	3 050	5 950	8 500
50	55	20	26 900	59 000	2 750	6 050	8 000
	55	27	35 000	83 000	3 600	8 450	8 000
	55	30	39 500	96 500	4 000	9 800	8 000
	56	20	28 100	54 500	2 870	5 600	8 000
	58	20	38 500	67 500	3 950	6 900	8 500
	58	25	48 500	90 500	4 950	9 200	8 500
51	56	50.8	60 000	166 000	6 100	16 900	8 000
52	60	24	46 000	86 000	4 700	8 750	8 000

Bearing Numbers	Mass (g)
	approx
<b>FWF-404513</b>	18
<b>FWF-404517A</b>	23
<b>FWF-404527</b>	36
<b>FWJ-404530</b>	40
<b>FWF-404630</b>	50
<b>FWF-404820</b>	45
<b>FWF-404825</b>	56
<b>FWF-404834</b>	76
<b>FBN-424717</b>	24
<b>FBN-424727</b>	38
<b>FWF-425020</b>	47
<b>FWF-434817</b>	25
<b>FWF-434827</b>	39
<b>FWJ-434931</b>	55
<b>FWF-455017</b>	26
<b>FWF-455027</b>	41
<b>FWJ-455135</b>	61
<b>FWF-455320</b>	50
<b>FWF-455325</b>	62
<b>FWF-465237W</b>	75
<b>FWF-475217</b>	27
<b>FWF-475227</b>	43
<b>FWF-475230</b>	47
<b>FWF-475528</b>	73
<b>FBN-485323Z</b>	47
<b>FWF-485420</b>	39
<b>FWF-505520</b>	37
<b>FWF-505527</b>	50
<b>FWF-505530</b>	56
<b>FBN-505620</b>	51
<b>FWF-505820</b>	61
<b>FWF-505825</b>	77
<b>FWF-515650WZ</b>	95
<b>FWF-526024</b>	46



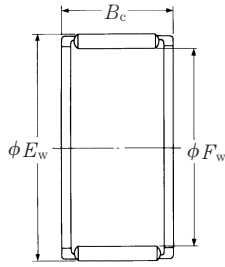
FWF

FWF...W

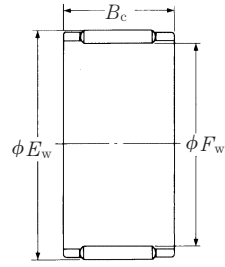
FBN

Inscribed Circle

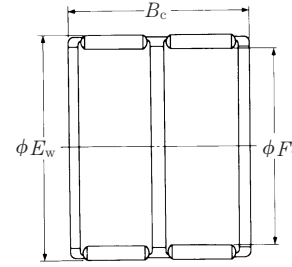
Diameter 55 — 73 mm



FWF



FBN



FWF...W

Boundary Dimensions (mm)			Basic Load Ratings				Limiting Speeds (min <sup>-1</sup> )
F <sub>w</sub>	E <sub>w</sub>	B <sub>c</sub> -0.035	(N)		{kgf}		
			C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>	Oil
<b>55</b>	60	20	27 500	62 500	2 800	6 350	7 500
	60	27	36 000	89 000	3 700	9 100	7 500
	60	30	41 000	105 000	4 200	10 700	7 500
	61	20	31 000	64 000	3 150	6 500	7 500
	61	30	47 000	109 000	4 750	11 100	7 500
	63	20	40 000	73 000	4 100	7 450	7 500
<b>56</b>	61	30	38 500	97 500	3 950	9 950	7 100
	61	33.5	41 000	105 000	4 150	10 700	7 100
<b>57</b>	73	30	89 500	129 000	9 150	13 100	7 500
<b>58</b>	64	40	54 000	132 000	5 500	13 500	7 100
	65	26.5	45 000	95 000	4 600	9 700	7 100
<b>60</b>	65	20	29 000	69 000	2 960	7 050	6 700
	65	27	38 000	98 500	3 900	10 000	6 700
	65	41	50 500	141 000	5 150	14 400	6 700
	66	20	33 000	71 500	3 350	7 300	6 700
	66	30	50 000	122 000	5 100	12 400	6 700
	67	23	41 500	86 500	4 250	8 800	6 700
<b>65</b>	68	20	41 500	78 000	4 200	7 950	6 700
	68	23	47 500	94 000	4 850	9 600	6 700
	68	25	52 000	105 000	5 300	10 700	6 700
	68	27	51 500	103 000	5 250	10 500	6 700
<b>68</b>	70	20	27 900	67 500	2 850	6 900	6 300
	70	30	44 500	123 000	4 550	12 500	6 300
	73	30	61 000	132 000	6 200	13 400	6 300
<b>70</b>	74	20	33 000	74 000	3 350	7 550	6 000
	74	30	52 000	135 000	5 300	13 700	6 000
<b>72</b>	76	20	35 500	82 500	3 600	8 450	5 600
	76	30	53 500	141 000	5 450	14 400	5 600
	78	30	63 000	140 000	6 400	14 300	6 000
<b>73</b>	78	40	60 000	163 000	6 100	16 700	5 600
	79	21	42 000	93 000	4 300	9 500	5 600
<b>73</b>	79	20	36 000	85 500	3 650	8 700	5 600
	79	30	55 000	147 000	5 600	15 000	5 600

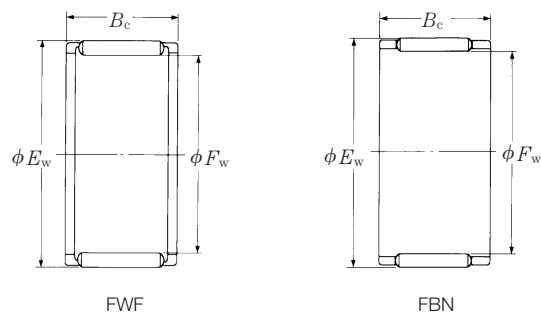
Bearing Numbers	Mass (g)
	approx
<b>FWF-556020</b>	41
<b>FWF-556027</b>	55
<b>FWF-556030</b>	61
<b>FWF-556120</b>	53
<b>FWF-556130</b>	81
<b>FWF-556320</b>	70
<b>FWF-556325</b>	85
<b>FWF-566130</b>	62
<b>FWF-566133Z</b>	70
<b>FWF-577330A</b>	77
<b>FWF-586440W</b>	104
<b>FWF-586526Z</b>	81
<b>FWF-606520</b>	44
<b>FWF-606527</b>	62
<b>FWF-606541W</b>	91
<b>FWF-606620</b>	57
<b>FWF-606630</b>	87
<b>FWF-606723</b>	73
<b>FWF-606820</b>	73
<b>FWF-606823</b>	84
<b>FWF-606825</b>	91
<b>FWF-606827</b>	98
<b>FBN-657020</b>	48
<b>FWF-657030</b>	72
<b>FWF-657330</b>	120
<b>FBN-687420</b>	60
<b>FWF-687430</b>	91
<b>FWF-707620</b>	62
<b>FWF-707630</b>	93
<b>FWF-707830</b>	125
<b>FWF-727840W</b>	145
<b>FWF-727921</b>	79
<b>FBN-737920</b>	65
<b>FWF-737930</b>	97

FWF

FBN

Inscribed Circle

Diameter 75 — 150 mm



FWF

FBN

Boundary Dimensions (mm)			Basic Load Ratings				Limiting Speeds (min <sup>-1</sup> )
<i>F<sub>w</sub></i>	<i>E<sub>w</sub></i>	<i>B<sub>c</sub></i> <small>-0.2 -0.35</small>	<i>C<sub>r</sub></i> (N)	<i>C<sub>or</sub></i> (N)	<i>C<sub>r</sub></i> {kgf}	<i>C<sub>or</sub></i> {kgf}	
<b>75</b>	81	20	37 000	89 500	3 750	9 100	5 300
	81	30	54 500	147 000	5 550	15 000	5 300
	83	30	65 000	151 000	6 650	15 400	5 600
<b>78</b>	85	40	76 500	207 000	7 850	21 100	5 300
<b>80</b>	86	20	38 000	94 000	3 850	9 600	5 000
	86	30	57 000	160 000	5 850	16 300	5 000
	88	30	69 000	166 000	7 050	17 000	5 000
<b>85</b>	92	30	64 000	169 000	6 500	17 200	4 800
	93	25	59 000	139 000	6 050	14 200	4 800
	93	30	71 000	176 000	7 250	17 900	4 800
<b>90</b>	98	30	70 000	177 000	7 150	18 000	4 500
	<b>95</b>	103	69 500	177 000	7 100	18 100	4 300
<b>100</b>	108	30	75 500	201 000	7 700	20 500	4 000
<b>105</b>	113	27	69 500	183 000	7 100	18 700	3 800
	113	30	72 500	193 000	7 400	19 700	3 800
<b>110</b>	118	30	78 500	218 000	8 000	22 300	3 600
<b>115</b>	123	35	92 500	274 000	9 450	28 000	3 400
<b>120</b>	128	25	69 500	192 000	7 100	19 600	3 400
	<b>125</b>	133	93 500	284 000	9 550	29 000	3 200
<b>130</b>	138	25	71 500	205 000	7 300	20 900	3 000
	<b>135</b>	143	107 000	345 000	10 900	35 500	3 000
<b>145</b>	153	30	89 000	281 000	9 050	28 700	2 800
	<b>150</b>	160	149 000	475 000	15 200	48 000	2 600

Bearing Numbers	Mass (g)
	approx
<b>FBN-758120</b>	66
<b>FWF-758130</b>	100
<b>FWF-758330</b>	135
<b>FWF-788540</b>	160
<b>FWF-808620</b>	71
<b>FWF-808630</b>	105
<b>FWF-808830</b>	145
<b>FWF-859230</b>	130
<b>FWF-859325</b>	125
<b>FWF-859330</b>	150
<b>FWF-909830</b>	160
<b>FWF-9510330</b>	175
<b>FWF-10010830</b>	185
<b>FWF-10511327</b>	165
<b>FWF-10511330</b>	185
<b>FWF-11011830</b>	195
<b>FWF-11512335</b>	235
<b>FWF-12012825</b>	190
<b>FWF-12513335</b>	255
<b>FWF-13013825</b>	220
<b>FWF-13514338</b>	275
<b>FWF-14515330</b>	290
<b>FWF-15016043</b>	505

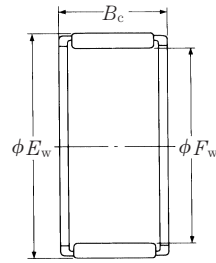
WJ

WJC

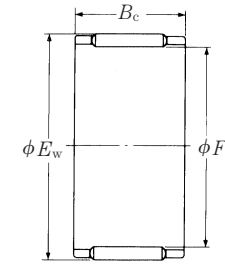
WJP

Inscribed Circle

Diameter 9.525 — 44.450 mm



WJ



WJC, WJP

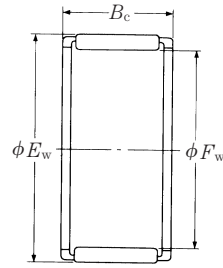
$F_w$	Boundary Dimensions (mm, inch)				Basic Load (N)		
	$E_w$	$B_c$ -0.08	$C_r$	$C_{or}$			
<b>9.525</b>	0.3750	12.700	0.5000	9.52	0.3750	3 900	4 000
		12.700	0.5000	12.70	0.5000	5 450	6 150
<b>12.700</b>	0.5000	15.875	0.6250	12.70	0.5000	6 350	8 100
		15.875	0.6250	15.88	0.6250	8 000	10 900
<b>14.288</b>	0.5625	17.462	0.6875	12.70	0.5000	6 900	9 350
<b>15.875</b>	0.6250	19.050	0.7500	12.70	0.5000	7 100	10 000
		22.225	0.8750	15.88	0.6250	15 400	17 300
		22.225	0.8750	22.22	0.8750	21 100	25 900
<b>19.050</b>	0.7500	25.400	1.0000	25.40	1.0000	26 600	36 500
<b>20.638</b>	0.8125	26.988	1.0625	22.22	0.8750	24 600	33 500
<b>22.225</b>	0.8750	28.575	1.1250	25.40	1.0000	29 000	42 500
<b>25.400</b>	1.0000	33.338	1.3125	19.05	0.7500	27 800	36 000
		33.338	1.3125	25.40	1.0000	36 500	51 500
<b>28.575</b>	1.1250	38.100	1.5000	25.40	1.0000	42 000	56 500
		38.100	1.5000	31.75	1.2500	51 500	73 500
<b>31.750</b>	1.2500	41.275	1.6250	19.05	0.7500	33 000	42 500
		41.275	1.6250	25.40	1.0000	44 000	61 000
		41.275	1.6250	31.75	1.2500	53 500	79 500
		41.275	1.6250	38.10	1.5000	63 000	98 000
<b>34.925</b>	1.3750	44.450	1.7500	25.40	1.0000	45 500	66 000
		44.450	1.7500	31.75	1.2500	55 500	85 500
<b>38.100</b>	1.5000	47.625	1.8750	25.40	1.0000	47 000	70 500
		47.625	1.8750	31.75	1.2500	57 500	91 500
		47.625	1.8750	38.10	1.5000	68 000	113 000
<b>41.275</b>	1.6250	57.150	2.2500	42.86	1.6875	96 500	130 000
<b>44.450</b>	1.7500	53.975	2.1250	19.05	0.7500	39 000	58 000
		53.975	2.1250	25.40	1.0000	51 500	83 500
		53.975	2.1250	38.10	1.5000	74 500	134 000

Ratings	{kgf}		Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers	Mass (g)
	$C_r$	$C_{or}$			
			Oil		approx
	400	410	45 000	<b>WJC-060806</b>	3
	555	625	45 000	<b>WJC-060808</b>	4
	645	825	34 000	<b>WJC-081008</b>	4
	815	1 110	34 000	<b>WJC-081010</b>	6
	705	955	30 000	<b>WJC-091108</b>	6
	725	1 020	26 000	<b>WJC-101208</b>	6
	1 570	1 770	28 000	<b>WJ-101410</b>	13
	2 150	2 640	28 000	<b>WJ-101414</b>	18
	2 710	3 750	22 000	<b>WJ-121616</b>	25
	2 510	3 450	20 000	<b>WJ-131714</b>	21
	2 960	4 350	20 000	<b>WJ-141816</b>	28
	2 830	3 700	17 000	<b>WJ-162112</b>	35
	3 700	5 250	17 000	<b>WJ-162116</b>	43
	4 300	5 750	15 000	<b>WJ-182416</b>	58
	5 250	7 500	15 000	<b>WJ-182420</b>	72
	3 350	4 350	14 000	<b>WJ-202612</b>	51
	4 450	6 250	14 000	<b>WJ-202616</b>	61
	5 500	8 100	14 000	<b>WJ-202620</b>	73
	6 450	10 000	14 000	<b>WJ-202624</b>	105
	4 650	6 700	12 000	<b>WJ-222816</b>	67
	5 700	8 750	12 000	<b>WJ-222820</b>	83
	4 800	7 200	11 000	<b>WJ-243016</b>	78
	5 850	9 350	11 000	<b>WJ-243020</b>	90
	6 900	11 500	11 000	<b>WJ-243024</b>	120
	9 850	13 300	11 000	<b>*WJP-263627</b>	205
	4 000	5 950	9 500	<b>WJ-283412</b>	62
	5 250	8 500	9 500	<b>WJ-283416</b>	84
	7 600	13 700	9 500	<b>WJ-283424</b>	145

\* These bearings have polyamide cages. The maximum permissible operating temperature for these bearings is 100°C for continued operation and 120°C for short periods.

WJ

Inscribed Circle Diameter 50.800 — 127.000 mm



WJ

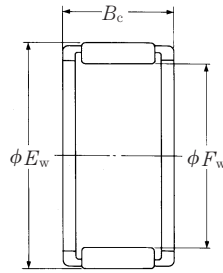
$F_w$	Boundary Dimensions (mm, inch)					Basic Load (N)	
	$E_w$	$B_c$ <small>-0.038</small>	$C_r$	$C_{or}$			
<b>50.800</b>	2.0000	60.325	2.3750	19.05	0.7500	42 500	67 500
		60.325	2.3750	25.40	1.0000	56 000	96 500
		60.325	2.3750	31.75	1.2500	68 500	126 000
		60.325	2.3750	38.10	1.5000	81 000	155 000
<b>52.388</b>	2.0625	61.912	2.4375	25.40	1.0000	57 500	101 000
<b>53.975</b>	2.1250	63.500	2.5000	25.40	1.0000	53 000	92 000
		63.500	2.5000	38.10	1.5000	78 000	151 000
<b>55.562</b>	2.1875	65.088	2.5625	19.05	0.7500	44 000	73 500
		65.088	2.5625	25.40	1.0000	58 500	105 000
<b>57.150</b>	2.2500	66.675	2.6250	25.40	1.0000	53 500	94 000
<b>60.325</b>	2.3750	69.850	2.7500	38.10	1.5000	81 000	165 000
<b>63.500</b>	2.5000	73.025	2.8750	25.40	1.0000	55 500	102 000
		73.025	2.8750	38.10	1.5000	82 500	171 000
<b>69.850</b>	2.7500	79.375	3.1250	25.40	1.0000	57 500	110 000
<b>76.200</b>	3.0000	85.725	3.3750	25.40	1.0000	59 000	118 000
		85.725	3.3750	38.10	1.5000	85 000	189 000
<b>82.550</b>	3.2500	92.075	3.6250	25.40	1.0000	61 000	126 000
		92.075	3.6250	38.10	1.5000	87 500	201 000
<b>88.900</b>	3.5000	98.425	3.8750	25.40	1.0000	62 500	134 000
		101.600	4.0000	25.40	1.0000	79 000	147 000
		101.600	4.0000	38.10	1.5000	113 000	234 000
<b>101.600</b>	4.0000	114.300	4.5000	25.40	1.0000	83 000	163 000
		114.300	4.5000	38.10	1.5000	119 000	259 000
<b>127.000</b>	5.0000	152.400	6.0000	38.10	1.5000	211 000	360 000

Ratings $C_r$	$C_{or}$ {kgf}	Limiting Speeds (min <sup>-1</sup> ) Oil	Bearing Numbers	Mass (g)
				approx
4 300	6 850	8 500	<b>WJ-323812</b>	85
5 700	9 850	8 500	<b>WJ-323816</b>	105
7 000	12 800	8 500	<b>WJ-323820</b>	125
8 250	15 800	8 500	<b>WJ-323824</b>	145
5 850	10 300	8 000	<b>WJ-333916</b>	99
5 400	9 400	8 000	<b>WJ-344016</b>	100
7 950	15 400	8 000	<b>WJ-344024</b>	150
4 500	7 500	7 500	<b>WJ-354112</b>	85
5 950	10 700	7 500	<b>WJ-354116</b>	105
5 450	9 600	7 500	<b>WJ-364216</b>	105
8 300	16 800	7 100	<b>WJ-384424</b>	185
5 650	10 400	6 700	<b>WJ-404616</b>	135
8 450	17 500	6 700	<b>WJ-404624</b>	180
5 850	11 200	6 000	<b>WJ-445016</b>	125
6 050	12 000	5 300	<b>WJ-485416</b>	160
8 700	19 200	5 300	<b>WJ-485424</b>	215
6 200	12 900	5 000	<b>WJ-525816</b>	145
8 950	20 500	5 000	<b>WJ-525824</b>	220
6 400	13 700	4 500	<b>WJ-566216</b>	175
8 050	15 000	4 500	<b>WJ-566416</b>	215
11 500	23 800	4 500	<b>WJ-566424</b>	360
8 450	16 600	4 000	<b>WJ-647216</b>	240
12 100	26 400	4 000	<b>WJ-647224</b>	370
21 500	36 500	3 400	<b>WJ-809624</b>	1 000

**CAGE & NEEDLE ROLLER ASSEMBLIES**

For Large Ends of Connecting Rods

Inscribed Circle Diameter 12 — 30 mm



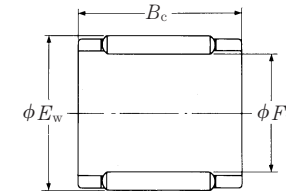
FWF...E

Boundary Dimensions (mm)			Basic Load Ratings (N)				Bearing Numbers	Mass (g) approx
$F_w$	$E_w$	$B_c$ <small><math>\pm 0.04</math></small>	$C_r$	$C_{or}$	$C_r$	$C_{or}$		
<b>12</b>	16	10	6 100	6 500	620	665	<b>FWF-121610-E</b>	4.0
<b>14</b>	19	10	7 800	8 050	795	820	<b>FWF-141910-E</b>	6.2
	20	12	8 900	8 600	910	880	<b>FWF-142012-E</b>	8.3
<b>15</b>	19	9	5 650	6 250	575	640	<b>FWF-15199-E</b>	4.1
	20	10	7 300	7 600	745	775	<b>FWF-152010-E</b>	6.0
	21	10	7 950	7 500	810	765	<b>FWF-152110-E</b>	8.5
<b>16</b>	21	11	8 650	9 600	880	980	<b>FWF-162111-E</b>	7.5
	22	12	9 500	9 600	965	980	<b>FWF-162212-E</b>	9.5
<b>18</b>	23	14	11 800	14 800	1 200	1 510	<b>FWF-182314-E</b>	10
	24	12	10 000	10 600	1 020	1 080	<b>FWF-182412-E</b>	11
<b>20</b>	26	12	12 200	14 100	1 250	1 440	<b>FWF-202612-E</b>	13
	26	17	16 800	21 200	1 710	2 160	<b>FWF-202617-E</b>	17
	28	18	18 100	19 400	1 840	1 970	<b>FWF-202818-E</b>	25
<b>22</b>	28	14	13 900	17 100	1 420	1 740	<b>FWF-222814-E</b>	14
	29	15	16 300	19 000	1 660	1 930	<b>FWF-222915-E</b>	19
	32	16	19 700	19 400	2 010	1 970	<b>FWF-223216-E</b>	31
<b>23</b>	31	16	17 600	19 400	1 800	1 980	<b>FWF-233116-E</b>	23
<b>24</b>	30	15	15 600	20 300	1 590	2 070	<b>FWF-243015-E</b>	17
	30	17	17 900	24 300	1 830	2 480	<b>FWF-243017-E</b>	19
	31	20	21 600	27 800	2 200	2 840	<b>FWF-243120-E</b>	30
<b>25</b>	32	16	17 700	21 900	1 810	2 230	<b>FWF-253216-E</b>	24
<b>28</b>	35	16	18 400	23 700	1 880	2 410	<b>FWF-283516-E</b>	25
<b>29.75</b>	36.75	16.5	19 600	26 000	1 990	2 650	<b>FWF-293616Z-E</b>	28
<b>30</b>	37	16	21 900	30 500	2 230	3 100	<b>FWF-303716-E</b>	29
	38	18	25 500	34 000	2 600	3 450	<b>FWF-303818-E</b>	35

**NSK NEEDLE BEARING**

For Small Ends of Connecting Rods

Inscribed Circle Diameter 9 — 19 mm



FBN...E

Boundary Dimensions (mm)			Basic Load Ratings (N)				Bearing Numbers	Mass (g) approx
$F_w$	$E_w$	$B_c$ <small><math>\pm 0.04</math></small>	$C_r$	$C_{or}$	$C_r$	$C_{or}$		
<b>9</b>	12	11.5	4 200	4 500	430	460	<b>FBN-91211Z-E</b>	3.5
<b>10</b>	14	12.7	5 900	5 950	605	610	<b>FBN-101412Z-E</b>	5.0
<b>12</b>	15	14.3	6 400	8 400	655	855	<b>FBN-121514Z-E</b>	4.8
	16	13	7 250	8 200	740	835	<b>FBN-121613-E</b>	6.4
	16	15.5	8 500	10 000	865	1 020	<b>FBN-121615Z-E</b>	7.0
	16	16	8 500	10 000	865	1 020	<b>FBN-121616-E</b>	7.5
<b>14</b>	18	12	6 950	8 050	710	820	<b>FBN-141812-E</b>	6.5
	18	16.5	9 250	11 600	945	1 180	<b>FBN-141816Z-E</b>	8.5
	18	18	10 700	14 000	1 090	1 430	<b>FBN-141818-E</b>	11.5
	18	20	9 550	12 000	975	1 230	<b>FBN-141820-E1</b>	13
<b>15</b>	19	18	11 300	15 300	1 150	1 560	<b>FBN-151918-E</b>	11
	21	18	12 900	13 900	1 310	1 420	<b>FBN-152118-E</b>	13
<b>16</b>	20	22	13 700	20 000	1 400	2 040	<b>FBN-162022-E</b>	14
	20	23.5	14 900	22 300	1 520	2 280	<b>FBN-162023Z-E</b>	15
	21	20	14 200	18 100	1 450	1 840	<b>FBN-162120-E</b>	16
<b>17</b>	21	23	14 800	22 500	1 510	2 290	<b>FBN-172123-E</b>	16
<b>18</b>	22	17	11 500	16 500	1 170	1 680	<b>FBN-182217-E</b>	12
	22	22	14 200	21 600	1 440	2 200	<b>FBN-182222-E</b>	15
	22	23.6	15 400	24 100	1 570	2 460	<b>FBN-182223Z-E</b>	16
<b>19</b>	23	23.7	16 000	25 800	1 630	2 630	<b>FBN-192323Z-E</b>	17

Please consult NSK when making a selection.

## DRAWN CUP NEEDLE ROLLER BEARINGS

### METRIC DESIGN

Pages

Open Type with Cage and Closed End Type with Cage	Inscribed Circle Diameter	10–55 mm	B46–B53
Sealed Type with Cage	Inscribed Circle Diameter	8–50 mm	B54–B57
Thin, Open Type with Cage	Inscribed Circle Diameter	18–82 mm	B58–B59
Full Complement Open Type and Full Complement Closed End Type	Inscribed Circle Diameter	8–55 mm	B60–B63

### INCH DESIGN

Open Type with Cage and Closed End Type with Cage	Inscribed Circle Diameter	9.525–50.800 mm	B64–B67
Full Complement Open Type and Full Complement Closed End Type	Inscribed Circle Diameter	11.112–50.800 mm	B68–B75
Full Complement and Grease-Retained Roller Type	Inscribed Circle Diameter	3.969–47.625 mm	B76–B79

### EXTRA SMALL • MINIATURE

Metric Design Open Type with Cage and Closed End Type with Cage	Inscribed Circle Diameter	3–9 mm	B80–B81
Full Complement Metric Design Open Type and Full Complement Closed End Type	Inscribed Circle Diameter	3.036–9 mm	B82–B83
Inch Design Open Type with Cage and Closed End Type with Cage	Inscribed Circle Diameter	3.175–9.525 mm	B84–B85
Inch Design Full Complement Open Type and Full Complement Closed End Type	Inscribed Circle Diameter	3.175–9.525 mm	B86–B87

NSK drawn cup needle roller bearings (with a cage and full complement of rollers) have a unique outer ring structure. They have the following features: the thinnest outer ring among rolling bearings, high load capacity, high maximum permissive load owing to the use of carefully selected special alloy steel plates, a surface-hardened cage with high resistance to wear, high limiting speed, and ease of mounting.

### DESIGN AND TYPES

NSK drawn cup needle roller bearings consist of an outer ring made of carefully selected alloy steel that is surface-hardened after precise pressing, rollers made of vacuum-degassed bearing steel that are given a grinding finish after through-hardening, and a cage that guides the rollers correctly on the pitch diameter.

The bent lip of the drawn cup, which is the outer ring, improves rigidity, holds the rollers and cage in place, and functions as a labyrinth seal to prevent foreign matter from entering and lubrication from leaking. The inside of the outer ring's bending part is hardened, and has sufficient wear resistance against the contact of the roller or cage.



The bearing numbers of NSK drawn cup bearings are shown in combination with bearing codes and dimension numbers.

The bearing codes are shown in **Table 1**.

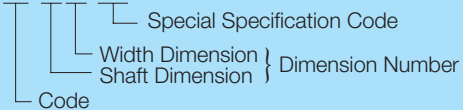
**Table 1 Bearing Codes**

Items		With Cage Assembly		Full Complement	
		Open	Closed End	Open	Closed End
Standard Series	Metric	FJ, FJP	MFJ	F, NF, DD	MF, MNF
	Inch	J, JP	MJ	B, Y	M
High Load Series	Metric	FJL, FJH	MFJL, MFJH	FH, NFH	MFH
	Inch	JH	MJH	BH, YH	MH

The dimension number has the following meaning:

Metric	The first one or two digits indicate the shaft's dimensions, and the following digits indicate the width, both expressed in mm units.
Inch	The first one or two digits indicate the shaft's dimensions, and the following digits indicate the width, both expressed in units of 1/16 of an inch. With closed ends, the number "1" is added following the dimension number.

**(Example) FJ-1612-OH**



FJ means a metric open-type bearing with a cage.

**Special Specifications**

The bearing is manufactured in accordance with special specifications depending on operating conditions. In this case, the code is indicated with the bearing number followed by a hyphen and a letter or alphanumeric combination.

(Example) OH .... outer ring with oil hole

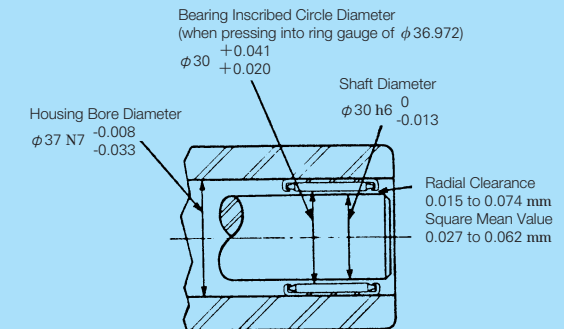
**ACCURACY**

Although standard drawn cup needle bearings perform well for general use, higher-accuracy drawn cup needle bearings are sometimes required such as when dispersion of radial internal clearance needs to be sharply decreased, when eccentric effects should be minimized, or when using only a few bearings to share the load evenly. However, standard bearings are still sufficient for almost all other occasions. Considering the higher cost of high-accuracy bearings, please consult NSK when selecting such bearings.

**INTERNAL CLEARANCE**

The radial internal clearance when a drawn cup needle bearing is mounted in a housing varies depending on the bearing, shaft and housing bore tolerances. Therefore, the tolerances for the shaft and housing bore should be narrower when reducing the range of radial internal clearance.

When the dimensional tolerance for each part is as shown in **Fig. 1** (Example of **F-3020-1**), the radial internal clearance ranges from 0.015 to 0.074 mm.



**Fig. 1 Radial Internal Clearance**

**APPLICATION**

**Shaft and housing specifications**

For drawn cup needle bearings, the shaft is generally used as a substitute for the inner ring. Since the outer ring of drawn cup needle bearings is made of a thin steel plate, the correct shape and dimensional accuracy are achieved after press fitting the regular housing. The dimensional accuracy and hardness of the shaft and housing bore directly affect bearing performance. Therefore, the following specifications should be satisfied.

**(1) Accuracy, Roughness and Hardness**

Accuracy, roughness and hardness of the shaft and housing bore should satisfy the specifications shown in **Table 2**.

**(2) Shaft Inclination**

Shaft inclination due to deflection by external force and mounting error of the bearing should be within the values found in **Table 3**.

**Table 2 Accuracy, Roughness, and Hardness**

Category	Shaft	Housing Bore
Out-of-Roundness Tolerance	$\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Cylindricity Tolerance	$\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Roughness, Ra	0.4	1.6
Hardness	HRC58 to 64 (HRC60 to 64 is favorable) Proper depth of hardening layer required	—

**Remarks** For details, refer to Section **5.2** on page A34 and Section **5.3** on page A35.

**Table 3 Permissible Shaft Inclination**

Bearing Width (mm)		Permissible Inclination (mm/mm)	
over	incl	With Cage	Full Complement
	25	0.0015	0.0010
25	50	0.0010	0.0005
50		0.0005	0.0005

**(3) Housing Rigidity**

To maintain the accuracy of drawn cup needle bearings, it is necessary to design the housing thick enough to minimize deformation when load is applied.

Split housings can only be used with drawn cup needle bearings after press fitting the bearing into a cylindrical sleeve.

**FITTING**

Drawn cup needle bearings perform as designed only after proper fitting. It is necessary to use the fitting tolerances shown in **Table 4** for the shaft and housing bore.

The figures in **Table 4** are for fits when housing materials are rigid steel or cast iron.

The fit should be adjusted as follows in accordance with operating conditions:

**(1) Oscillating motion**

In order to reduce radial internal clearance, the shaft's fitting tolerance should be js6 (j6).

**(2) Outer ring rotation**

For metric bearings, the fitting tolerances of the shaft and housing bore should be f6 and R7, respectively.

For inch bearings, 0.013 mm should be reduced from both fitting tolerances of shaft and housing bore.

**(3) The housing is made from light alloy or steel with a thickness of less than 6 mm.**

The fitting tolerances of housing bore should be minimized to approximately 0.013 to 0.025 mm, provided that the optimized value should be determined by mounting into the actual housing because the value may vary depending on housing material and shape. Please contact NSK for details.

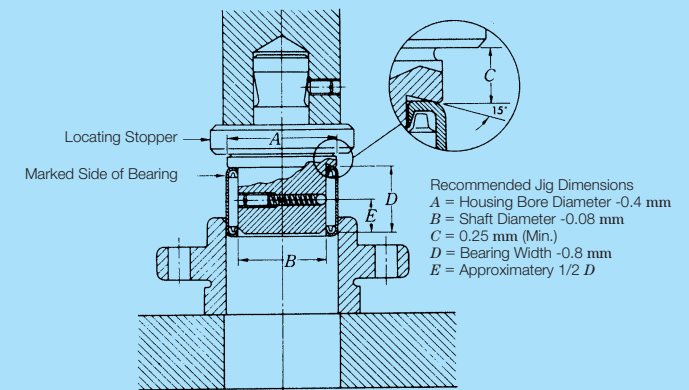
**Table 4 Recommended Fits**

Category		Fitting Tolerance				
		Shaft	Housing Bore			
Metric	F, FJ	h6	N7			
	FJL	h6	J7			
Inch	B, BH, J, JH, Y, YH	h6	Nominal Outside Diameter $D$ , mm		Tolerance, mm	
			over	incl	high	low
			7.144 ( $9/32$ )		+0.013	0
			7.144 ( $9/32$ )	8.731 ( $11/32$ )	0	+0.013
		8.731 ( $11/32$ )		J7	J7	

**MOUNTING**

When an drawn cup needle roller bearing is pressed into a housing bore, it is necessary to use an appropriate jig to prevent deformation of and damage to the outer ring, as shown in **Fig. 2**. The following precautions apply when mounting:

- (1) The marked-side face should be placed onto the shoulder of the jig.
- (2) A hand press should be used for press fitting. Avoid using a hammer or other such instruments.
- (3) No snap ring or shoulder to determine the position of the bearing is necessary. However, when using a housing with a shoulder, the bearing side face should not touch the shoulder, in order to prevent bearing deformation.
- (4) The guide and locating stopper (**Fig. 2**) are installed in order to apply press fitting accurately. The ball detent shown in **Fig. 2** helps the jig hold the bearing and prevent roller inclination while facilitating mounting work.

**Fig. 2 Example of Jig****Inspection of Drawn Cup Needle Bearings**

Deformation to a certain degree due to heat treatment is inevitable even though the outer ring of drawn cup needle bearings is processed by precise deep drawing. However, once the bearing is pressed into the regular housing, this deformation is corrected and the bearing performs to the full potential. Therefore, it is not appropriate to measure the drawn cup outside diameter before mounting. Correct inspection is carried out according to following procedures:

- (1) The bearing that is to be subject to the test is pressed into a ring gauge of given dimensions.
- (2) The inscribed circle diameter at the GO and NO-GO plug gauges is inspected.

Metric inspection gauge dimensions are shown in **Table 5**.

**Table 6** shows tolerance for the roller inscribed circle diameter based on ISO standards.

For bearings based on ISO standards, "-1" is added at the end of the bearing number. **Table 7** shows inch inspection gauge dimensions.



Table 5 Inspection Gauge Dimensions (General Metric)

Units: mm

Nominal Roller Inscribed Circle Diameter, $F_w$	Bore Diameter of Ring Gauge		Plug Gauge	
	F, MF, FH, MFH, NF, MNF, NFH, FJ, MFJ	FJL, MFJL	GO Gauge	NO-GO Gauge
4	7.996	—	4.023	4.048
5	8.996	—	5.023	5.048
6	9.996	—	6.028	6.053
7	10.995	—	7.031	7.056
8	11.995	15.010	8.031	8.056
9	12.995	16.010	9.031	9.056
10	13.995	17.010	10.031	10.056
12	15.995	19.012	12.031	12.056
FH12	17.995	—	12.031	12.056
13	18.993	—	13.034	13.059
14	19.993	22.012	14.034	14.059
NF14	18.993	—	14.034	14.059
15	20.993	22.012	15.034	15.059
16	21.993	24.012	16.034	16.059
17	22.972	23.991	17.013	17.038
18	23.972	24.991	18.013	18.038
20	25.972	26.991	20.013	20.038
22	27.972	28.991	22.013	22.038
NFH22	30.987	—	24.015	24.035
24	—	30.989	24.013	24.038
NFH24	31.967	—	24.013	24.038
25	31.967	32.989	25.013	25.038
28	34.967	36.989	28.013	28.038
30	36.967	39.989	30.013	30.038
32	—	41.989	32.013	32.038
35	41.967	44.989	35.013	35.043
40	46.967	49.989	40.013	40.043
45	51.961	54.988	45.013	45.043
50	57.961	61.988	50.013	50.043
55	62.961	66.988	55.013	55.043

**Remarks** This is the gauge dimension for inspection of minimum diameter,  $F_w$ , of roller inscribed circle diameter.

Table 6 Ring Gauge of Drawn Cup Needle Roller Bearings and Tolerance of Roller Inscribed Circle Diameter (ISO Standards)

[ FJ, FJH, MFJ and MFJH ]  
[ F, FH, MF and MFH ]

Units: mm

Nominal Roller Inscribed Circle Diameter, $F_w$	Bore Diameter of Ring Gauge	Tolerance for Roller Inscribed Circle Diameter, $F_w^{(1)}$	
		min	max
3	6.484	3.007	3.021
4	7.984	4.010	4.028
5	8.984	5.010	5.028
6	9.984	6.010	6.028
7	10.980	7.013	7.031
8	11.980	8.013	8.031
H 8	13.980	8.013	8.031
9	12.980	9.013	9.031
H 9	14.980	9.013	9.031
10	13.980	10.013	10.031
H10	15.980	10.013	10.031
12	15.980	12.016	12.034
H12	17.980	12.016	12.034
13	18.976	13.016	13.034
14	19.976	14.016	14.034
15	20.976	15.016	15.034
16	21.976	16.016	16.034
17	22.976	17.016	17.034
18	23.976	18.016	18.034
20	25.976	20.020	20.041
22	27.976	22.020	22.041
25	31.972	25.020	25.041
28	34.972	28.020	28.041
30	36.972	30.020	30.041
35	41.972	35.025	35.050
40	46.972	40.025	40.050
45	51.967	45.025	45.050
50	57.967	50.025	50.050
55	62.967	55.030	55.060

**Note** <sup>(1)</sup> When using a cylinder instead of an inner ring,  $F_w^{min}$  is the diameter of the cylinder at which the internal clearance is zero in at least one radial direction. ( $F_w^{min}$  is the minimum diameter of each inscribed circle diameter where deviation is suspected.)

**Remarks** To measure the roller inscribed circle diameter, use the following plug gauges:  
GO gauge: The same dimensions as the minimum tolerance of the roller inscribed circle diameter,  $F_w$   
NO-GO gauge: The dimensions should be the maximum tolerance of roller inscribed circle diameter,  $F_w$ , plus 0.002 mm

Table 7 Inspection Gauge Dimensional Table (Inch)

B, M, J, MJ, Y and JP			
Units: mm			
Nominal Roller Inscribed Circle Diameter, $F_n$	Bore Diameter of Ring Gauge	Plug Gauge	
		GO Gauge	NO-GO Gauge
3.175 ( $\frac{1}{8}$ )	6.363	3.195	3.220
3.969 ( $\frac{5}{32}$ )	7.155	3.990	4.015
4.762 ( $\frac{3}{16}$ )	8.730	4.783	4.808
6.350 ( $\frac{1}{4}$ )	11.125	6.388	6.413
7.938 ( $\frac{5}{16}$ )	12.713	7.976	8.001
9.525 ( $\frac{3}{8}$ )	14.300	9.563	9.588
11.112 ( $\frac{7}{16}$ )	15.888	11.151	11.176
12.700 ( $\frac{1}{2}$ )	17.475	12.738	12.763
14.288 ( $\frac{9}{16}$ )	19.063	14.326	14.351
15.875 ( $\frac{5}{8}$ )	20.650	15.913	15.938
17.462 ( $\frac{11}{16}$ )	22.238	17.501	17.526
19.050 ( $\frac{3}{4}$ )	25.387	19.063	19.088
20.638 ( $\frac{13}{16}$ )	26.975	20.650	20.675
22.225 ( $\frac{7}{8}$ )	28.562	22.238	22.263
23.812 ( $\frac{15}{16}$ )	30.150	23.825	23.850
25.400 ( 1 )	31.737	25.413	25.438
26.988 ( $1\frac{1}{16}$ )	33.325	27.000	27.025
28.575 ( $1\frac{1}{8}$ )	34.912	28.588	28.613
30.162 ( $1\frac{3}{16}$ )	38.087	30.175	30.200
31.750 ( $1\frac{1}{4}$ )	38.087	31.763	31.788
33.338 ( $1\frac{5}{16}$ )	41.262	33.350	33.378
34.925 ( $1\frac{3}{8}$ )	41.262	34.938	34.966
38.100 ( $1\frac{1}{2}$ )	47.612	38.113	38.143
41.275 ( $1\frac{5}{8}$ )	50.787	41.288	41.318
44.450 ( $1\frac{3}{4}$ )	53.962	44.463	44.496
47.625 ( $1\frac{7}{8}$ )	57.137	47.638	47.671
50.800 ( 2 )	60.312	50.815	50.848

BH, MH, JH, MJH and YH

Units: mm			
Nominal Roller Inscribed Circle Diameter, $F_n$	Bore Diameter of Ring Gauge	Plug Gauge	
		GO Gauge	NO-GO Gauge
7.938 ( $\frac{5}{16}$ )	14.300	7.976	8.001
9.525 ( $\frac{3}{8}$ )	15.888	9.563	9.588
11.112 ( $\frac{7}{16}$ )	17.475	11.151	11.176
12.700 ( $\frac{1}{2}$ )	19.063	12.738	12.763
14.288 ( $\frac{9}{16}$ )	20.650	14.326	14.351
15.875 ( $\frac{5}{8}$ )	22.238	15.913	15.938
17.462 ( $\frac{11}{16}$ )	23.825	17.501	17.526
19.050 ( $\frac{3}{4}$ )	26.975	19.063	19.088
20.638 ( $\frac{13}{16}$ )	28.562	20.650	20.675
22.225 ( $\frac{7}{8}$ )	30.150	22.238	22.263
25.400 ( 1 )	33.325	25.413	25.438
28.575 ( $1\frac{1}{8}$ )	38.087	28.588	28.613
31.750 ( $1\frac{1}{4}$ )	41.262	31.763	31.788
34.925 ( $1\frac{3}{8}$ )	44.437	34.938	34.966

## Drawn Cup Needle Bearings with Seals

Drawn cup needle roller-bearing with seals can be sealed on one or both sides. The bearings are packed with lithium soap-based grease and can be operated under regular conditions in normal operating ranges for long periods without replenishment. The seal made of nitrile synthetic rubber reinforced with a steel plate and serves as a guide for the side face of the cage. The operating temperature range is limited because of the rubber seal, ranging from  $-10^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$  for continuous use from  $-25^{\circ}\text{C}$  to  $+120^{\circ}\text{C}$  for short periods of use.

The various types of drawn cup needle bearings with seals are shown in

Table 8.

Table 8 Types of Drawn Cup Needle Roller Bearings with Seals

Code	Description
FJT, FJLT, FJHT	Drawn cup with seal on one side
FJTT, FJLTT, FJHTT	Drawn cup with seals on both sides
MFJT, MFJLT, MFJHT	Closed end, drawn cup with seal on one side

With Cage

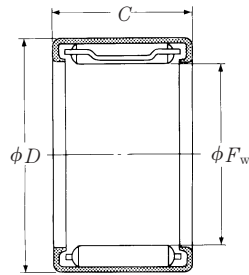
FJ • FJH (Open Type)

FJL

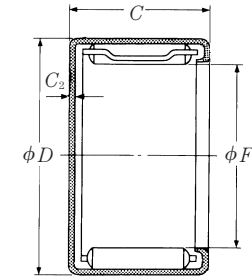
MFJ • MFJH (Closed Type)

MFJL

Inscribed Circle Diameter 10 — 16 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}		Limiting Speeds (min <sup>-1</sup> ) Oil	
	$D$	$C$ -0.25	$C_2$ max	$C_t$	$P_{max}$				
10	14	10	0.8	3 500	360	1 760	179	32 000	
	14	15	—	5 550	570	3 150	325	32 000	
	16	10	1.0	4 900	500	2 100	214	34 000	
	17	10	1.0	4 900	500	1 990	203	36 000	
	17	12	1.0	5 700	580	2 410	246	36 000	
	17	15	1.0	7 850	800	3 650	375	36 000	
	17	20	1.0	11 200	1 140	5 750	585	36 000	
	12	16	10	0.8	4 150	420	2 210	225	26 000
12	18	12	1.0	6 450	655	3 050	310	28 000	
	19	12	1.0	6 650	675	2 950	300	28 000	
	19	15	1.0	9 200	935	4 500	455	28 000	
	19	20	1.0	13 000	1 330	7 000	715	28 000	
	19	25	1.0	16 600	1 690	9 550	975	28 000	
	13	19	12	1.0	6 950	710	3 400	345	26 000
	14	20	12	1.0	6 500	665	3 250	335	24 000
	14	20	16	1.0	9 500	970	5 300	540	24 000
22		16	1.1	11 600	1 180	5 700	580	24 000	
22		20	1.1	15 100	1 540	8 050	820	24 000	
15		21	10	—	5 850	595	2 770	283	22 000
21		12	1.0	7 650	780	3 900	400	22 000	
21		16	1.0	11 000	1 120	6 200	635	22 000	
22		10	1.0	6 450	655	2 880	294	22 000	
22		12	1.0	7 450	760	3 500	355	22 000	
15	22	15	1.0	10 300	1 050	5 300	540	22 000	
	22	20	1.0	14 700	1 500	8 300	845	22 000	
	22	25	1.0	18 700	1 900	11 300	1 150	22 000	
	16	22	12	1.0	7 100	725	3 750	380	20 000
	22	16	1.0	10 400	1 060	6 050	620	20 000	
	24	16	1.1	13 100	1 330	6 700	685	20 000	
	24	20	1.1	17 100	1 740	9 500	970	20 000	

Bearing Numbers				Mass (g)		Matching Inner Rings
FJ FJH	Open FJL	Closed MFJ MFJH	MFJL	Open	approx Closed	
FJ-1010 FJ-1015L FJH-1010		MFJ-1010		3.6	4.1	FIR-071010
		—		5.4	—	FIR-071015
		MFJH-1010		6.1	6.6	FIR-071010
	FJL-1010 FJL-1012L FJL-1015 FJL-1020		MFJL-1010 MFJL-1012L MFJL-1015 MFJL-1020	7.0 8.4 11 14	7.8 9.3 12 16	FIR-071010 FIR-071012 FIR-071015 —
FJ-1210 FJH-1212		MFJ-1210		4.1	4.5	FIR-081210
		MFJH-1212		7.7	9.0	FIR-081212
	FJL-1212L		MFJL-1212L	9.8	11	FIR-081212
	FJL-1215 FJL-1220 FJL-1225L		MFJL-1215 MFJL-1220 MFJL-1225L	12 16 20	14 19 24	FIR-081215 — —
FJ-1312		MFJ-1312		8.6	9.5	FIR-101312
FJ-1412 FJ-1416		MFJ-1412		10	11	FIR-101412
		MFJH-1416		13	14	FIR-101416
	FJL-1416 FJL-1420L		MFJL-1416L MFJL-1420L	17 21	19 24	FIR-101416 FIR-101420
FJ-1510 FJ-1512 FJ-1516		—		8.1	—	FIR-101510
		MFJ-1512		10	11	FIR-101512
		MFJH-1516		13	14	FIR-121516
	FJL-1510L FJL-1512L FJL-1515		MFJL-1510L MFJL-1512L MFJL-1515	9.8 12 14	11 13 16	FIR-101510 FIR-101512 FIR-101515
	FJL-1520 FJL-1525L		MFJL-1520 MFJL-1525L	20 24	22 27	FIR-101520 FIR-101525
FJ-1612 FJ-1616		MFJ-1612		11	12	FIR-121612
		MFJH-1616		14	15	FIR-121616
	FJL-1616L FJL-1620L		MFJL-1616L MFJL-1620L	19 24	21 27	FIR-121616 FIR-121620

With Cage

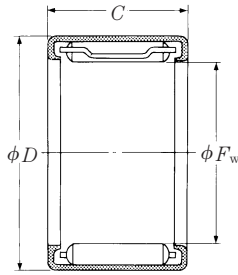
FJ (Open Type)

FJL

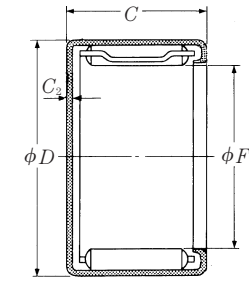
MFJ (Closed Type)

MFJL

Inscribed Circle Diameter 17 — 25 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Speeds (min <sup>-1</sup> ) Oil	
	$D$	$C$ <sub>-0.25</sub>	$C_2$ max	$C_r$		$P_{max}$			
17	23	12	1.0	8 450	860	4 450	455	19 000	
	23	16	1.0	12 100	1 230	7 100	720	19 000	
	24	15	1.0	10 800	1 110	5 700	580	20 000	
	24	20	1.0	15 400	1 570	8 950	910	20 000	
18	24	25	1.0	19 600	2 000	12 200	1 240	20 000	
	24	12	1.0	7 650	780	4 200	430	18 000	
	24	16	1.0	11 200	1 140	6 800	695	18 000	
	25	13	1.0	9 300	945	4 700	480	18 000	
	25	15	1.0	11 400	1 160	6 100	620	18 000	
	25	17	1.0	13 300	1 360	7 500	765	18 000	
	25	20	1.0	16 100	1 640	9 600	975	18 000	
	25	25	1.0	20 500	2 090	13 100	1 330	18 000	
20	26	12	1.0	8 150	835	4 650	475	16 000	
	26	16	1.0	11 900	1 210	7 550	770	16 000	
	26	20	1.0	15 300	1 560	10 500	1 070	16 000	
	27	15	1.0	12 300	1 260	6 900	705	16 000	
	27	20	1.0	17 500	1 790	10 900	1 110	16 000	
	27	25	1.0	22 300	2 270	14 800	1 510	16 000	
	27	30	1.0	26 800	2 730	18 700	1 910	16 000	
22	28	12	1.0	8 650	880	5 150	525	14 000	
	28	16	1.0	12 600	1 290	8 350	850	14 000	
	28	20	1.0	16 200	1 660	11 500	1 180	14 000	
	29	10	1.0	7 950	810	4 000	405	15 000	
	29	15	1.0	12 700	1 300	7 300	745	15 000	
	29	20	1.0	18 100	1 840	11 500	1 170	15 000	
	29	25	1.0	23 000	2 350	15 700	1 600	15 000	
	29	30	1.0	27 700	2 820	19 800	2 020	15 000	
	25	32	16	1.0	15 200	1 550	9 350	955	13 000
		32	20	1.0	19 800	2 020	13 100	1 340	13 000
32		26	1.0	26 200	2 670	18 800	1 920	13 000	
33		10	1.0	8 800	895	4 300	435	13 000	
33		15	1.0	15 400	1 570	8 800	895	13 000	
33		20	1.0	21 900	2 240	13 900	1 420	13 000	
33		25	1.0	28 000	2 850	19 000	1 940	13 000	
33		30	1.0	33 500	3 450	24 100	2 460	13 000	

Bearing Numbers				Mass (g)		Matching Inner Rings	
Open		Closed		approx			
FJ	FJL	MFJ	MFJL	Open	Closed		
FJ-1712		MFJ-1712		10	11	—	—
FJ-1716		MFJ-1716		14	16	—	—
	FJL-1715		MFJL-1715	16	18	FIR-121715	—
	FJL-1720L		MFJL-1720L	21	24	FIR-121720	—
	FJL-1725L		MFJL-1725L	27	30	FIR-121725	—
FJ-1812		MFJ-1812		12	14	FIR-151812	—
FJ-1816		MFJ-1816		16	18	FIR-151816	—
	FJL-1813		MFJL-1813	14	16	—	—
	FJL-1815		MFJL-1815	17	19	FIR-151815	—
	FJL-1817L		MFJL-1817L	20	22	—	—
	FJL-1820L		MFJL-1820L	22	25	FIR-151820	—
	FJL-1825		MFJL-1825	28	31	FIR-151825	—
FJ-2012		MFJ-2012		13	15	FIR-172012	—
FJ-2016		MFJ-2016		17	19	FIR-172016	—
FJ-2020		MFJ-2020		22	24	FIR-152020	FIR-172020
	FJL-2015L		MFJL-2015	19	21	FIR-152015	—
	FJL-2020		MFJL-2020	24	27	FIR-152020	FIR-172020
	FJL-2025L		MFJL-2025L	30	33	FIR-152025	—
	FJL-2030L		MFJL-2030L	37	41	FIR-152030	—
FJ-2212		MFJ-2212		14	17	FIR-172212	—
FJ-2216		MFJ-2216		19	22	FIR-172216	—
FJ-2220		MFJ-2220		23	26	FIR-172220	—
	FJL-2210L		MFJL-2210L	13	15	FIR-172210	—
	FJL-2215L		MFJL-2215L	20	22	FIR-172215	—
	FJL-2220L		MFJL-2220L	27	30	FIR-172220	—
	FJL-2225L		MFJL-2225L	33	37	FIR-172225	—
	FJL-2230L		MFJL-2230L	40	44	FIR-172230	—
FJ-2516		MFJ-2516		24	27	FIR-202516	—
FJ-2520		MFJ-2520		31	34	FIR-202520	—
FJ-2526		MFJ-2526		40	43	FIR-202526	—
	FJL-2510		MFJL-2510	17	19	FIR-202510	—
	FJL-2515		MFJL-2515L	26	29	FIR-202515	—
	FJL-2520		MFJL-2520	35	39	FIR-202520	—
	FJL-2525L		MFJL-2525L	43	48	FIR-202525	—
	FJL-2530		MFJL-2530	52	58	FIR-202530	—

With Cage

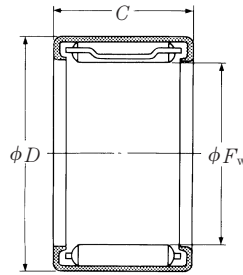
FJ (Open Type)

FJL

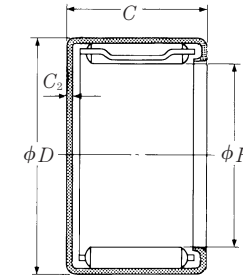
MFJ (Closed Type)

MFJL

Inscribed Circle Diameter 28 — 40 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Speeds (min <sup>-1</sup> ) Oil	
	$D$	$C$ <sub>-0.25</sub>	$C_2$ max	$C_r$		$P_{max}$			
<b>28</b>	35	16	1.0	15 600	1 590	9 950	1 020	11 000	
	35	20	1.0	20 500	2 090	14 200	1 450	11 000	
	35	26	1.0	26 900	2 750	20 200	2 060	11 000	
	37	20	1.0	25 400	2 590	15 500	1 580	11 000	
	37	30	1.0	39 000	4 000	27 100	2 760	11 000	
<b>30</b>	37	16	1.0	15 600	1 590	10 100	1 030	10 000	
	37	20	1.0	19 400	1 970	13 300	1 360	10 000	
	37	26	1.0	26 000	2 660	19 500	1 990	10 000	
	40	15	1.3	17 200	1 750	9 100	925	11 000	
	40	20	1.3	25 800	2 630	15 300	1 560	11 000	
	40	25	1.3	33 500	3 450	21 600	2 200	11 000	
	40	30	1.3	41 000	4 200	27 800	2 840	11 000	
<b>32</b>	42	20	1.3	26 700	2 720	16 200	1 650	10 000	
	42	30	1.3	42 500	4 300	29 400	3 000	10 000	
<b>35</b>	42	12	1.0	12 000	1 230	7 550	770	9 000	
	42	16	1.0	18 100	1 850	12 800	1 300	9 000	
	42	20	1.0	23 600	2 410	17 900	1 830	9 000	
	42	26	1.0	31 500	3 200	25 800	2 630	9 000	
	45	12	1.3	13 200	1 350	6 650	680	9 000	
	45	15	1.3	18 200	1 860	10 100	1 030	9 000	
	45	20	1.3	27 400	2 790	17 000	1 740	9 000	
	45	25	1.3	36 000	3 650	24 000	2 450	9 000	
	45	30	1.3	43 500	4 450	31 000	3 150	9 000	
	<b>40</b>	47	16	1.0	18 600	1 890	13 600	1 390	7 500
		47	20	1.0	23 500	2 400	18 500	1 890	7 500
47		26	1.0	31 500	3 200	26 900	2 740	7 500	
	50	15	1.3	19 900	2 030	11 600	1 180	8 000	
	50	20	1.3	29 900	3 050	19 600	2 000	8 000	
	50	25	1.3	39 000	3 950	27 600	2 810	8 000	
	50	30	1.3	47 500	4 850	35 500	3 650	8 000	

Bearing Numbers				Mass (g)		Matching Inner Rings
Open		Closed		approx		
FJ	FJL	MFJ	MFJL	Open	Closed	
<b>FJ-2816</b>		<b>MFJ-2816</b>		27	31	<b>FIR-222816</b> —
<b>FJ-2820</b>		<b>MFJ-2820</b>		34	38	<b>FIR-222820</b> —
<b>FJ-2826</b>		<b>MFJ-2826</b>		45	49	<b>FIR-222826</b> —
	<b>FJL-2820L</b>		<b>MFJL-2820L</b>	44	48	<b>FIR-222820</b> —
	<b>FJL-2830L</b>		<b>MFJL-2830L</b>	65	72	<b>FIR-222830</b> —
<b>FJ-3016L</b>		<b>MFJ-3016L</b>		26	31	— —
<b>FJ-3020</b>		<b>MFJ-3020</b>		35	39	<b>FIR-253020</b> —
<b>FJ-3026</b>		<b>MFJ-3026</b>		46	50	<b>FIR-253026</b> —
	<b>FJL-3015L</b>		<b>MFJL-3015L</b>	49	55	<b>FIR-253015</b> —
	<b>FJL-3020L</b>		<b>MFJL-3020L</b>	52	58	<b>FIR-253020</b> —
	<b>FJL-3025L</b>		<b>MFJL-3025L</b>	65	72	<b>FIR-253025</b> —
	<b>FJL-3030L</b>		<b>MFJL-3030L</b>	78	86	<b>FIR-253030</b> —
	<b>FJL-3220</b>		<b>MFJL-3220</b>	55	62	<b>FIR-283220</b> —
	<b>FJL-3230</b>		<b>MFJL-3230</b>	82	91	<b>FIR-283230</b> —
<b>FJ-3512</b>		<b>MFJ-3512</b>		24.3	30	<b>FIR-303512</b> —
<b>FJ-3516</b>		<b>MFJ-3516</b>		32	38	— —
<b>FJ-3520</b>		<b>MFJ-3520</b>		41	45	<b>FIR-303520</b> —
<b>FJ-3526</b>		<b>MFJ-3526</b>		54	58	<b>FIR-303526</b> —
	<b>FJL-3512</b>		<b>MFJL-3512</b>	36	40	<b>FIR-303512</b> —
	<b>FJL-3515</b>		<b>MFJL-3515</b>	44	49	<b>FIR-303515</b> —
	<b>FJL-3520L</b>		<b>MFJL-3520L</b>	60	67	<b>FIR-303520</b> —
	<b>FJL-3525L</b>		<b>MFJL-3525L</b>	74	82	<b>FIR-303525</b> —
	<b>FJL-3530L</b>		<b>MFJL-3530L</b>	90	100	<b>FIR-303530</b> —
<b>FJ-4016</b>		<b>MFJ-4016</b>		34	43	— —
<b>FJ-4020</b>		<b>MFJ-4020</b>		46	51	<b>FIR-354020</b> —
<b>FJ-4026</b>		<b>MFJ-4026</b>		60	65	<b>FIR-354026</b> —
	<b>FJL-4015L</b>		<b>MFJL-4015L</b>	50	55	<b>FIR-354015</b> —
	<b>FJL-4020L</b>		<b>MFJL-4020L</b>	67	74	<b>FIR-354020</b> —
	<b>FJL-4025L</b>		<b>MFJL-4025L</b>	84	93	<b>FIR-354025</b> —
	<b>FJL-4030L</b>		<b>MFJL-4030L</b>	100	110	<b>FIR-354030</b> —

With Cage

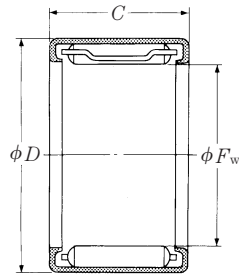
FJ (Open Type)

FJL

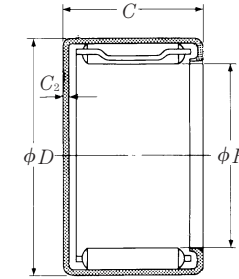
MFJ (Closed Type)

MFJL

Inscribed Circle Diameter 45 — 55 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Speeds (min <sup>-1</sup> ) Oil
	$D$	$C$ <small>-0.25</small>	$C_2$ max	$C_r$		$P_{max}$		
<b>45</b>	52	16	1.0	19 900	2 030	15 400	1 570	6 700
	52	20	1.0	25 500	2 600	21 200	2 160	6 700
	52	26	1.0	34 000	3 450	30 500	3 100	6 700
	55	20	1.3	31 000	3 200	21 300	2 170	7 100
	55	25	1.3	40 500	4 150	30 000	3 050	7 100
	55	30	1.3	49 500	5 050	38 500	3 950	7 100
<b>50</b>	58	20	1.1	28 900	2 940	23 100	2 350	6 300
	58	24	1.1	36 000	3 700	30 500	3 150	6 300
	62	12	1.3	21 200	2 160	11 600	1 180	6 300
	62	15	1.3	24 200	2 470	13 800	1 400	6 300
	62	20	1.3	37 000	3 800	23 700	2 420	6 300
	62	25	1.3	48 500	4 950	33 500	3 450	6 300
	62	30	1.3	59 500	6 050	43 500	4 450	6 300
	<b>55</b>	63	20	1.1	30 000	3 100	25 100	2 560
	63	24	1.1	37 500	3 850	33 500	3 400	5 600
	67	30	1.3	62 500	6 350	47 500	4 850	5 600
	67	40	1.3	81 500	8 350	67 000	6 850	5 600

Bearing Numbers				Mass (g)		Matching Inner Rings	
Open		Closed		approx			
FJ	FJL	MFJ	MFJL	Open	Closed		
<b>FJ-4516</b>		<b>MFJ-4516</b>		39	50	—	—
<b>FJ-4520</b>		<b>MFJ-4520</b>		53	59	<b>FIR-404520</b>	—
<b>FJ-4526</b>		<b>MFJ-4526</b>		68	74	<b>FIR-404526</b>	—
	<b>FJL-4520L</b>		<b>MFJL-4520L</b>	74	82	<b>FIR-404520</b>	—
	<b>FJL-4525L</b>		<b>MFJL-4525L</b>	94	105	<b>FIR-404525</b>	—
	<b>FJL-4530L</b>		<b>MFJL-4530L</b>	110	125	<b>FIR-404530</b>	—
<b>FJ-5020L</b>		<b>MFJ-5020</b>		56	71	<b>FIR-455020</b>	—
<b>FJ-5024</b>		<b>MFJ-5024</b>		69	84	—	—
	<b>FJL-5012L</b>		<b>MFJL-5012L</b>	60	66	<b>FIR-455012</b>	—
	<b>FJL-5015L</b>		<b>MFJL-5015L</b>	75	83	<b>FIR-455015</b>	—
	<b>FJL-5020L</b>		<b>MFJL-5020L</b>	100	110	<b>FIR-455020</b>	—
	<b>FJL-5025L</b>		<b>MFJL-5025L</b>	125	140	<b>FIR-455025</b>	—
	<b>FJL-5030L</b>		<b>MFJL-5030L</b>	150	165	<b>FIR-455030</b>	—
<b>FJ-5520</b>		<b>MFJ-5520</b>		60	79	—	—
<b>FJ-5524</b>		<b>MFJ-5524</b>		72	90	—	—
	<b>FJL-5530L</b>		<b>MFJL-5530L</b>	155	180	—	—
	<b>FJL-5540L</b>		<b>MFJL-5540L</b>	195	220	—	—

Sealed Type With Cage

FJT (Open Type • One-Side Sealed Type)

FJHT

FJLT

FJTT (Open Type • Both-Side Sealed Type)

FJHTT

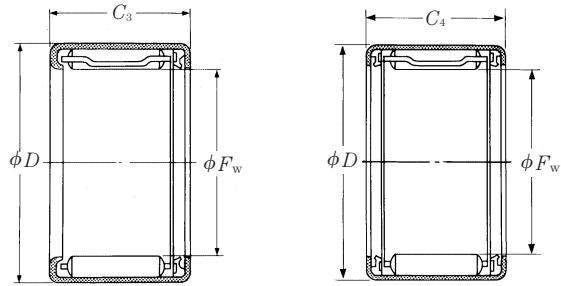
FJLTT

MFJT (Closed Type • Sealed Type)

MFJLT

Inscribed Circle

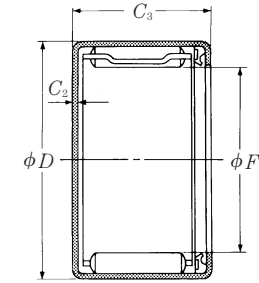
Diameter 8 — 22 mm



Open Type

FJT, FJHT, FJLT

FJTT, FJHTT, FJLTT



Closed Type

$F_w$	Boundary Dimensions (mm)					Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Speeds <sup>(1)</sup> (min <sup>-1</sup> )	Bearing	
	$D$	$C_3$ -0.25	$C_4$ -0.25	$C_2$ max	$C_r$	$P_{max}$	Open FJT FJHT	Open FJTT FJHTT				
8	12	12	14	0.8	2 840	289	1 270	130	22 000	<b>FJT-812</b>	<b>FJTT-814</b>	
	15	12	14	1.0	4 400	450	1 770	181	22 000			
10	14	12	14	0.8	3 500	360	1 760	179	19 000	<b>FJT-1012</b>	<b>FJTT-1014</b>	
	17	12	14	1.0	4 900	500	1 990	203	19 000			
12	16	12	14	0.8	4 150	420	2 210	225	15 000	<b>FJT-1212</b>	<b>FJTT-1214</b>	
	18	14	16	1.0	6 450	655	3 050	310	15 000	<b>FJHT-1214</b>	<b>FJHTT-1216</b>	
	19	14	16	1.0	6 650	675	2 950	300	15 000			
14	20	14	16	1.0	6 500	665	3 250	335	13 000	<b>FJT-1414</b>	<b>FJTT-1416</b>	
	22	19	22	1.1	11 600	1 180	5 700	580	13 000			
15	21	14	16	1.0	7 650	780	3 900	400	12 000	<b>FJT-1514</b>	<b>FJTT-1516</b>	
	22	13	16	1.0	6 450	655	2 880	294	12 000			
	22	18	21	1.0	10 300	1 050	5 300	540	12 000			
16	22	14	16	1.0	7 100	725	3 750	380	11 000	<b>FJT-1614</b>	<b>FJTT-1616</b>	
	22	18	20	1.0	10 400	1 060	6 050	620	11 000	<b>FJT-1618</b>	<b>FJTT-1620</b>	
	24	23	26	1.1	17 100	1 740	9 500	970	11 000			
17	24	18	21	1.0	10 800	1 110	5 700	580	11 000			
										<b>FJT-1814</b>	<b>FJTT-1816</b>	
18	24	14	16	1.0	7 650	780	4 200	430	10 000			
	25	18	21	1.0	11 400	1 160	6 100	620	10 000			
	25	20	23	1.0	13 300	1 360	7 500	765	10 000			
20	26	14	16	1.0	8 150	835	4 650	475	9 500	<b>FJT-2014</b>	<b>FJTT-2016</b>	
	26	18	20	1.0	11 900	1 210	7 550	770	9 500	<b>FJT-2018</b>	<b>FJTT-2020</b>	
	27	18	21	1.0	12 300	1 260	6 900	705	9 500			
	27	23	26	1.0	17 500	1 790	10 900	1 110	9 500			
22	28	14	16	1.0	8 650	880	5 150	525	8 500	<b>FJT-2214</b>	<b>FJTT-2216</b>	
	28	18	20	1.0	12 600	1 290	8 350	850	8 500	<b>FJT-2218</b>	<b>FJTT-2220</b>	
	29	18	21	1.0	12 700	1 300	7 300	745	8 500			
	29	23	26	1.0	18 100	1 840	11 500	1 170	8 500			

**Note** <sup>(1)</sup> This is the value when the speed at the seal contact surface is 10 m/sec under inner ring rotation. Under outer ring rotation, the limiting speed is half this value.

**Remarks** Standard grease is packed in the sealed drawn cup needle roller bearings unless otherwise specified.

Numbers	Closed MFJT	Open FJLT	Open FJLTT	Closed MFJLT	FJT FJHT FJLT	Mass (g) approx FJTT FJLTT FJHTT	MFJT MFJLT
<b>MFJT-812</b>		<b>FJLT-812</b>	<b>FJLTT-814</b>	<b>MFJLT-812</b>	3.1 6.4	3.5 6.8	3.6 7.0
<b>MFJT-1012</b>		<b>FJLT-1012</b>	<b>FJLTT-1014</b>	<b>MFJLT-1012</b>	4.1 7.5	4.6 8.0	4.6 8.3
<b>MFJT-1212</b> <b>MFJHT-1214</b>		<b>FJLT-1214</b>	<b>FJLTT-1216</b>	<b>MFJLT-1214</b>	5.1 8.7 11	6.1 9.7 12	5.5 9.2 12
<b>MFJT-1414</b>		<b>FJLT-1419</b>	<b>FJLTT-1422</b>	<b>MFJLT-1419</b>	11 18	13 19	12 20
<b>MFJT-1514</b>		<b>FJLT-1513</b> <b>FJLT-1518</b>	<b>FJLTT-1516</b> <b>FJLTT-1521</b>	<b>MFJLT-1513</b> <b>MFJLT-1518</b>	11 11 15	12 12 16	12 12 17
<b>MFJT-1614</b> <b>MFJT-1618</b>		<b>FJLT-1623</b>	<b>FJLTT-1626</b>	<b>MFJLT-1623</b>	12 15 25	13 16 16	13 16 28
		<b>FJLT-1718</b>	<b>FJLTT-1721</b>	<b>MFJLT-1718</b>	17	18	19
<b>MFJT-1814</b>		<b>FJLT-1818</b> <b>FJLT-1820</b>	<b>FJLTT-1821</b> <b>FJLTT-1823</b>	<b>MFJLT-1818</b> <b>MFJLT-1820</b>	13 18 21	15 19 22	15 20 22
<b>MFJT-2014</b> <b>MFJT-2018</b>		<b>FJLT-2018</b> <b>FJLT-2023</b>	<b>FJLTT-2021</b> <b>FJLTT-2026</b>	<b>MFJLT-2018</b> <b>MFJLT-2023</b>	14 18 20 25	17 21 22 27	16 20 22 28
<b>MFJT-2214</b> <b>MFJT-2218</b>		<b>FJLT-2218</b> <b>FJLT-2223</b>	<b>FJLTT-2221</b> <b>FJLTT-2226</b>	<b>MFJLT-2218</b> <b>MFJLT-2223</b>	16 21 22 29	18 23 24 30	19 24 24 32

Sealed Type With Cage

FJT (Open Type • One-Side Sealed Type)

FJLT

FJTT (Open Type • Both-Side Sealed Type)

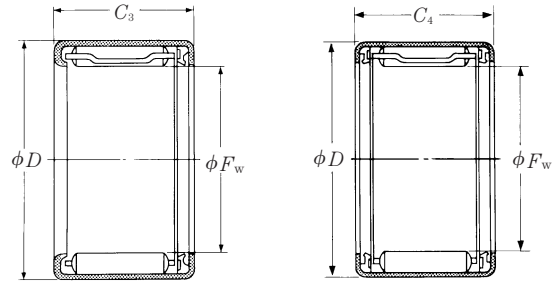
FJLTT

MFJT (Closed Type • Sealed Type)

MFJLT

Inscribed Circle

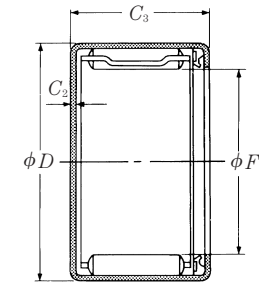
Diameter 25 — 50 mm



Open Type

FJT, FJLT

FJTT, FJLTT



Closed Type

F <sub>w</sub>	Boundary Dimensions (mm)				Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}		Limiting Speeds <sup>(1)</sup> (min <sup>-1</sup> )	Bearing	
	D	C <sub>3</sub> <sub>-0.25</sub>	C <sub>4</sub> <sub>-0.25</sub>	C <sub>2</sub> max	C <sub>r</sub>		P <sub>max</sub>			Open	
										FJT	FJTT
25	32	18	20	1.0	15 200	1 550	9 350	955	7 500	FJT-2518	FJTT-2520
	33	18	21	1.1	15 400	1 570	8 800	895			
	33	23	26	1.1	21 900	2 240	13 900	1 420			
28	35	18	20	1.0	15 600	1 590	9 950	1 020	6 700	FJT-2818	FJTT-2820
	37	23	26	1.0	25 400	2 590	15 500	1 580			
30	37	22	24	1.0	19 400	1 970	13 300	1 360	6 300	FJT-3022	FJTT-3024
	40	23	26	1.3	25 800	2 630	15 300	1 560			
	40	28	31	1.3	33 500	3 450	21 600	2 200			
35	42	22	24	1.0	23 600	2 410	17 900	1 830	5 300	FJT-3522	FJTT-3524
	45	18	21	1.3	18 200	1 860	10 100	1 030			
	45	28	31	1.3	36 000	3 650	24 000	2 450			
40	47	22	24	1.0	23 500	2 400	18 500	1 890	4 500	FJT-4022	FJTT-4024
	50	18	21	1.3	19 900	2 030	11 600	1 180			
	50	28	31	1.3	39 000	3 950	27 600	2 810			
45	52	22	24	1.0	25 500	2 600	21 200	2 160	4 000	FJT-4522	FJTT-4524
	55	23	26	1.3	31 000	3 200	21 300	2 170			
50	62	28	31	1.3	48 500	4 950	33 500	3 450	3 800		

Note (1) This is the value when the speed at the seal contact surface is 10 m/sec under inner ring rotation. Under outer ring rotation, the limiting speed is half this value.

Remarks Standard grease is packed in the sealed drawn cup needle roller bearings unless otherwise specified.

Numbers	Open			Closed	Mass (g) approx		
	Closed	Open			FJT FJLT	FJTT FJLTT	MFJT MFJLT
	MFJT	FJLT	FJLTT				
MFJT-2518							
		FJLT-2518	FJLTT-2521	MFJLT-2518	28	30	31
		FJLT-2523	FJLTT-2526	MFJLT-2523	28	31	31
MFJT-2818							
		FJLT-2823	FJLTT-2826	MFJLT-2823	37	39	41
					29	32	33
MFJT-3022							
		FJLT-2823	FJLTT-2826	MFJLT-2823	46	49	50
					29	32	33
MFJT-3022							
		FJLT-3023	FJLTT-3026	MFJLT-3023	40	42	44
		FJLT-3028	FJLTT-3031	MFJLT-3028	55	57	60
MFJT-3522							
		FJLT-3028	FJLTT-3031	MFJLT-3028	68	70	75
					46	49	50
MFJT-3522							
		FJLT-3518	FJLTT-3521	MFJLT-3518	47	50	52
		FJLT-3528	FJLTT-3531	MFJLT-3528	77	80	85
MFJT-4022							
		FJLT-3518	FJLTT-3521	MFJLT-3518	46	49	50
		FJLT-3528	FJLTT-3531	MFJLT-3528	77	80	85
MFJT-4022							
		FJLT-4018	FJLTT-4021	MFJLT-4018	52	55	57
		FJLT-4028	FJLTT-4031	MFJLT-4028	54	57	59
MFJT-4522							
		FJLT-4018	FJLTT-4021	MFJLT-4018	88	91	97
		FJLT-4028	FJLTT-4031	MFJLT-4028	88	91	97
MFJT-4522							
		FJLT-4523	FJLTT-4526	MFJLT-4523	61	64	67
		FJLT-5028	FJLTT-5031	MFJLT-5028	78	82	86
				130	135	145	

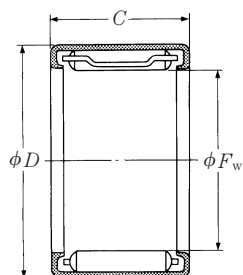


With Cage

Thin Type

DB

Inscribed Circle Diameter 18 — 82 mm



$F_w$	Boundary Dimensions (mm)		Basic Dynamic Load Ratings		Limiting Loads		Limiting Speeds ( $\text{min}^{-1}$ ) Oil
	$D$	$C$ 0 -0.25	(N)	{kgf}	(N)	{kgf}	
			$C_r$		$P_{\text{max}}$		
<b>18</b>	23	9.5	5 050	515	2 820	288	18 000
<b>33</b>	39	26	22 500	2 300	19 500	1 980	9 500
<b>39</b>	45	12	6 500	665	4 200	430	8 000
<b>55</b>	61	12	9 900	1 010	8 050	820	5 600
<b>82</b>	88	12	9 400	955	8 400	855	3 600

Bearing Numbers	Mass (g) approx
<b>DB501801</b>	7.5
<b>DB503303A</b>	44.4
<b>DB503901</b>	23
<b>DB505501</b>	35
<b>DB508201</b>	52

Full Complement Type

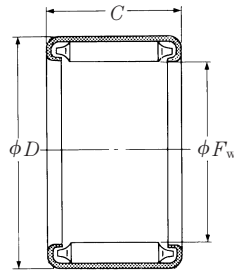
F • FH (Open Type)

NF

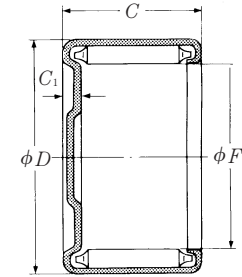
MF • MFH (Closed Type)

MNF

Inscribed Circle Diameter 8 — 20 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Speeds (min <sup>-1</sup> ) Oil
	$D$	$C$ -0.25	$C_1$ max	$C_t$		$P_{max}$		
<b>8</b>	14	10	1.9	5 550	565	2 980	305	10 000
	<b>9</b>	15	10	6 100	625	3 350	340	10 000
<b>10</b>	14	10	1.6	5 800	595	4 050	415	5 600
	16	10	1.9	6 650	680	3 700	375	9 000
<b>12</b>	16	10	1.6	6 450	660	4 700	480	5 000
	16	12	1.6	7 950	810	6 200	630	5 000
	18	12	1.9	9 000	920	5 700	580	7 500
<b>13</b>	19	12	1.9	9 550	975	6 100	625	7 100
	<b>14</b>	20	12	2.2	9 450	965	6 350	645
20		13	2.2	10 400	1 060	7 200	735	6 000
20		16	2.2	13 300	1 360	9 850	1 000	6 000
<b>15</b>	19	16	1.6	12 900	1 310	10 400	1 060	5 300
	19	20	1.6	16 100	1 640	13 800	1 410	5 300
	<b>15</b>	21	10	1.8	8 050	820	5 000	510
21		12	1.8	10 300	1 050	6 900	705	6 000
21		14	1.8	12 400	1 270	8 800	895	6 000
21		16	1.8	14 500	1 480	10 700	1 090	6 000
<b>16</b>	22	12	2.2	10 200	1 040	7 100	725	5 300
	22	16	2.2	14 400	1 460	11 100	1 130	5 300
<b>17</b>	23	12	1.8	11 300	1 150	7 750	790	5 600
	23	16	1.8	15 800	1 610	12 000	1 220	5 600
	23	20	1.8	20 200	2 060	16 300	1 670	5 600
<b>18</b>	24	12	2.2	10 900	1 110	7 900	805	5 000
	24	16	2.2	15 300	1 560	12 300	1 250	5 000
<b>20</b>	26	12	2.2	11 500	1 170	8 700	885	4 500
	26	16	2.2	16 200	1 650	13 500	1 380	4 500
	26	20	2.2	20 500	2 090	18 300	1 870	4 500

Bearing Numbers		Mass (g)		Matching Inner Rings	
Open F, FH NF	Closed MF, MFH MNF	Open	approx Closed		
<b>FH-810</b>	<b>MFH-810</b>	6.0	6.3	—	—
<b>FH-910</b>	<b>MFH-910</b>	6.4	6.8	—	—
<b>F-1010</b>	<b>MF-1010</b>	4.7	5.0	<b>FIR-071010</b>	—
<b>FH-1010</b>	<b>MFH-1010</b>	6.9	7.3	<b>FIR-071010</b>	—
<b>F-1210</b>	<b>MF-1210</b>	5.5	5.4	<b>FIR-081210</b>	—
<b>F-1212</b>	<b>MF-1212</b>	6.6	6.8	<b>FIR-081212</b>	—
<b>FH-1212</b>	<b>MFH-1212</b>	10	11	<b>FIR-081212</b>	—
<b>F-1312</b>	<b>MF-1312</b>	11	12	<b>FIR-101312</b>	—
<b>F-1412</b>	<b>MF-1412</b>	12	14	<b>FIR-101412</b>	—
<b>F-1413</b>	<b>MF-1413</b>	13	15	<b>FIR-101413</b>	—
<b>F-1416</b>	<b>MF-1416</b>	18	19	—	—
<b>NF-1416</b>	<b>MNF-1416</b>	12	13	<b>FIR-101416</b>	—
<b>NF-1420</b>	<b>MNF-1420</b>	16	17	<b>FIR-101420</b>	—
<b>F-1510</b>	<b>MF-1510</b>	10	12	<b>FIR-101510</b>	—
<b>F-1512</b>	<b>MF-1512</b>	12	14	<b>FIR-101512</b>	<b>FIR-121512</b>
<b>F-1514</b>	<b>MF-1514</b>	15	16	—	—
<b>F-1516</b>	<b>MF-1516</b>	17	18	<b>FIR-121516</b>	—
<b>F-1612</b>	<b>MF-1612</b>	14	15	<b>FIR-121612</b>	—
<b>F-1616</b>	<b>MF-1616</b>	18	20	<b>FIR-121616</b>	—
<b>F-1712</b>	<b>MF-1712</b>	14	15	—	—
<b>F-1716</b>	<b>MF-1716</b>	18	20	—	—
<b>F-1720</b>	<b>MF-1720</b>	23	24	<b>FIR-121720</b>	—
<b>F-1812</b>	<b>MF-1812</b>	14	16	<b>FIR-151812</b>	—
<b>F-1816</b>	<b>MF-1816</b>	19	22	<b>FIR-151816</b>	—
<b>F-2012</b>	<b>MF-2012</b>	17	19	<b>FIR-172012</b>	—
<b>F-2016</b>	<b>MF-2016</b>	22	25	<b>FIR-172016</b>	—
<b>F-2020</b>	<b>MF-2020</b>	28	30	<b>FIR-152020</b>	<b>FIR-172020</b>

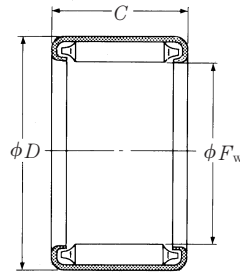
Full Complement Type

F (Open Type)

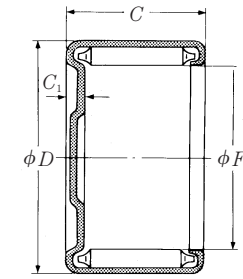
NFH

MF (Closed Type)

Inscribed Circle Diameter 22 — 55 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Speeds (min <sup>-1</sup> ) Oil
	$D$	$C$ -0.25	$C_1$ max	$C_t$		$P_{max}$		
<b>22</b>	28	10	2.2	9 400	960	6 850	700	4 000
	28	12	2.2	12 100	1 230	9 500	970	4 000
	28	16	2.2	17 100	1 740	14 800	1 510	4 000
	28	20	2.2	21 600	2 200	20 000	2 040	4 000
<b>24</b>	31	25	—	31 500	3 250	28 700	2 930	4 800
<b>25</b>	32	16	2.5	20 200	2 060	16 200	1 650	4 500
	32	20	2.5	25 900	2 640	22 200	2 260	4 500
	32	26	2.5	34 000	3 450	31 500	3 200	4 500
<b>28</b>	35	12	2.5	14 800	1 510	11 200	1 150	4 000
	35	16	2.5	21 300	2 170	17 900	1 820	4 000
	35	20	2.5	27 300	2 780	24 600	2 510	4 000
	35	26	2.5	35 500	3 650	34 500	3 550	4 000
<b>30</b>	37	14	2.5	18 900	1 930	15 500	1 590	3 800
	37	16	2.5	22 100	2 250	18 900	1 930	3 800
	37	20	2.5	28 400	2 900	26 200	2 670	3 800
	37	26	2.5	37 000	3 800	37 000	3 750	3 800
<b>35</b>	42	12	2.5	16 900	1 720	14 000	1 420	3 400
	42	16	2.5	24 000	2 450	22 000	2 240	3 400
	42	20	2.5	31 000	3 150	30 000	3 100	3 400
	42	26	2.5	40 000	4 100	42 500	4 350	3 400
<b>40</b>	47	16	2.5	25 700	2 620	24 900	2 540	3 000
	47	20	2.5	32 500	3 350	34 000	3 450	3 000
	47	26	2.5	43 000	4 350	48 000	4 900	3 000
<b>45</b>	52	16	2.5	27 300	2 790	27 800	2 840	2 600
	52	20	2.5	35 000	3 550	38 500	3 900	2 600
	52	26	2.5	45 500	4 650	54 000	5 500	2 600
<b>50</b>	58	20	2.8	39 500	4 050	41 500	4 250	2 800
	58	24	2.8	48 000	4 900	53 000	5 400	2 800
<b>55</b>	63	20	2.8	41 500	4 250	45 500	4 650	2 400
	63	24	2.8	50 500	5 150	58 000	5 950	2 400

Bearing Numbers		Mass (g)		Matching Inner Rings
Open F, NFH	Closed MF	Open approx	Closed	
<b>F-2210</b>	<b>MF-2210</b>	14	17	<b>FIR-172210</b> —
<b>F-2212</b>	<b>MF-2212</b>	18	21	<b>FIR-172212</b> —
<b>F-2216</b>	<b>MF-2216</b>	24	27	<b>FIR-172216</b> —
<b>F-2220</b>	<b>MF-2220</b>	30	33	<b>FIR-172220</b> —
<b>NFH-222A</b>	—	45	—	—
<b>F-2516</b>	<b>MF-2516</b>	31	35	<b>FIR-202516</b> —
<b>F-2520</b>	<b>MF-2520</b>	40	43	<b>FIR-202520</b> —
<b>F-2526</b>	<b>MF-2526</b>	52	55	<b>FIR-202526</b> —
<b>F-2812</b>	<b>MF-2812</b>	26	32	—
<b>F-2816</b>	<b>MF-2816</b>	35	40	<b>FIR-222816</b> —
<b>F-2820</b>	<b>MF-2820</b>	44	48	<b>FIR-222820</b> —
<b>F-2826</b>	<b>MF-2826</b>	57	62	<b>FIR-222826</b> —
<b>F-3014</b>	<b>MF-3014</b>	30	34	—
<b>F-3016</b>	<b>MF-3016</b>	35	40	—
<b>F-3020</b>	<b>MF-3020</b>	46	51	<b>FIR-253020</b> —
<b>F-3026</b>	<b>MF-3026</b>	61	66	<b>FIR-253026</b> —
<b>F-3512</b>	<b>MF-3512</b>	31	38	<b>FIR-303512</b> —
<b>F-3516</b>	<b>MF-3516</b>	42	49	—
<b>F-3520</b>	<b>MF-3520</b>	53	60	<b>FIR-303520</b> —
<b>F-3526</b>	<b>MF-3526</b>	70	76	<b>FIR-303526</b> —
<b>F-4016</b>	<b>MF-4016</b>	48	56	—
<b>F-4020</b>	<b>MF-4020</b>	60	69	<b>FIR-354020</b> —
<b>F-4026</b>	<b>MF-4026</b>	79	88	<b>FIR-354026</b> —
<b>F-4516</b>	<b>MF-4516</b>	53	64	—
<b>F-4520</b>	<b>MF-4520</b>	67	78	<b>FIR-404520</b> —
<b>F-4526</b>	<b>MF-4526</b>	88	99	<b>FIR-404526</b> —
<b>F-5020</b>	<b>MF-5020</b>	81	95	—
<b>F-5024</b>	<b>MF-5024</b>	98	110	—
<b>F-5520</b>	<b>MF-5520</b>	88	105	—
<b>F-5524</b>	<b>MF-5524</b>	105	125	—

With Cage

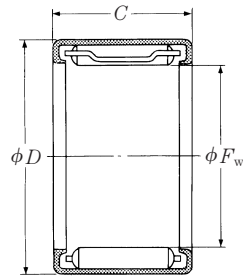
J (Open Type)

JH

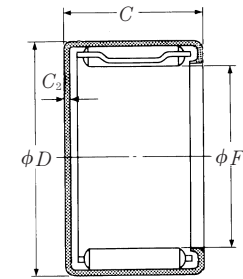
MJ (Closed Type)

MJH

Inscribed Circle Diameter 9.525 — 19.050 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}	
	$D$	$C$ <sub>-0.25</sub>	$C_2$ <sub>max</sub>	$C_r$	$P_{max}$					
<b>9.525</b>	0.3750	15.875	0.6250	12.70	0.5000	1.0	6 650	675	3 000	310
		15.875	0.6250	12.70	0.5000	1.0	5 800	595	3 100	315
<b>11.112</b>	0.4375	17.462	0.6875	12.70	0.5000	1.0	7 150	730	3 300	340
		17.462	0.6875	12.70	0.5000	1.0	6 350	650	3 500	360
<b>12.700</b>	0.5000	17.462	0.6875	7.92	—	1.0	3 150	325	1 440	147
		17.462	0.6875	12.70	0.5000	1.0	6 350	650	3 500	360
		17.462	0.6875	19.05	0.7500	—	10 100	1 030	6 450	655
		19.050	0.7500	11.13	—	1.0	6 450	655	2 930	298
<b>14.288</b>	0.5625	19.050	0.7500	12.70	0.5000	1.0	7 600	775	3 600	370
		19.050	0.7500	19.05	0.7500	1.0	12 400	1 260	6 800	690
		19.050	0.7500	11.13	—	1.0	5 350	545	2 860	292
		19.050	0.7500	12.70	0.5000	1.0	6 250	640	3 500	360
<b>15.875</b>	0.6250	20.638	0.8125	15.88	0.6250	1.0	8 200	835	5 000	510
		20.638	0.8125	12.70	0.5000	1.0	8 050	820	3 950	400
		20.638	0.8125	19.05	0.7500	1.0	13 100	1 330	7 350	750
		20.638	0.8125	12.70	0.5000	1.0	6 750	685	3 950	405
<b>17.462</b>	0.6875	22.225	0.8750	15.88	0.6250	1.0	8 850	900	5 600	570
		22.225	0.8750	19.05	0.7500	1.0	11 600	1 190	8 050	820
		22.225	0.8750	15.88	0.6250	1.0	11 600	1 190	6 400	655
		22.225	0.8750	25.40	1.0000	1.0	19 900	2 030	12 800	1 300
<b>19.050</b>	0.7500	23.812	0.9375	19.05	0.7500	1.0	11 500	1 170	8 050	820
		23.812	0.9375	15.88	0.6250	1.0	12 100	1 230	6 850	700
		23.812	0.9375	19.05	0.7500	1.0	15 000	1 530	9 000	915
		25.400	1.0000	9.52	0.3750	—	5 950	610	2 800	285
<b>19.050</b>	0.7500	25.400	1.0000	12.70	0.5000	—	10 000	1 020	5 450	555
		25.400	1.0000	15.88	0.6250	1.0	12 600	1 280	7 250	740
		25.400	1.0000	19.05	0.7500	1.0	15 600	1 590	9 600	980
		26.988	1.0625	19.05	0.7500	1.0	19 200	1 950	10 900	1 110

Remarks Sealed bearings are available upon the request.

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)		Matching Inner Rings	
	Oil	Open	Closed		Open	Closed		
38 000		J	JH	MJ	MJH			
			<b>JH-68</b>		<b>MJH-681</b>	8.2	8.6	— —
30 000	30 000	<b>J-78</b>		<b>MJ-781</b>	<b>MJH-781</b>	6.4	7.3	— —
			<b>JH-78</b>		<b>MJH-781</b>	9.1	9.5	— —
26 000	26 000	<b>J-85</b>		<b>MJ-851</b>		5.4	6.4	— —
		<b>J-88</b>		<b>MJ-881</b>		7.3	8.2	— —
26 000	26 000	<b>J-812</b>		—		7.7	—	— —
			<b>JH-87</b>		<b>MJH-871</b>	9.5	11	— —
26 000	26 000		<b>JH-88</b>		<b>MJH-881</b>	10	13	— —
			<b>JH-812</b>		<b>MJH-8121</b>	15	17	— —
22 000	22 000	<b>J-97</b>		<b>MJ-971</b>		7.3	8.6	— —
		<b>J-98</b>		<b>MJ-981</b>		8.2	9.5	<b>IR-68</b> —
24 000	24 000	<b>*J-910-F</b>		<b>*MJ-9101-F</b>		9.1	10	— —
			<b>JH-98</b>		<b>MJH-98</b>	11	13	<b>IR-68</b> —
20 000	20 000		<b>*JH-912-F</b>		<b>*MJH-9121-F</b>	14	16	— —
		<b>J-108</b>		<b>MJ-1081</b>		8.6	10	<b>IR-68-1</b> —
20 000	20 000	<b>J-1010</b>		<b>MJ-10101</b>		10	12	— —
		<b>J-1012</b>		<b>MJ-10121</b>		13	14	<b>IR-612-1</b> —
20 000	20 000		<b>JH-1010</b>		<b>MJH-10101</b>	15	18	— —
			<b>JH-1016</b>		<b>MJH-10161</b>	25	27	— —
18 000	19 000	<b>J-1112</b>		<b>MJ-11121</b>		16	18	— —
			<b>JH-1110</b>		<b>MJH-11101</b>	16	18	— —
17 000	17 000		<b>JH-1112</b>		<b>MJH-11121</b>	17	20	— —
		<b>J-126</b>		—		8.2	—	— —
17 000	17 000	<b>J-128</b>		—		12	—	<b>IR-88</b> —
		<b>J-1210</b>		<b>MJ-12101</b>		16	19	— —
17 000	18 000	<b>J-1212</b>		<b>MJ-12121</b>		20	20	<b>IR-812</b> —
			<b>JH-1212</b>		<b>MJH-12121</b>	24	26	<b>IR-812</b> —

\* These bearings have polyamide cages. The maximum permissible operating temperature for these bearings is 100°C for continued operation and 120°C for short periods.

DRAWN CUP NEEDLE ROLLER BEARINGS (INCH DESIGN)

With Cage

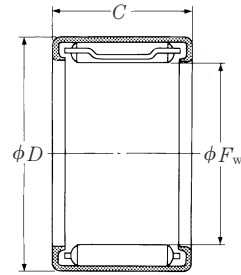
J (Open Type)

JH

MJ (Closed Type)

MJH

Inscribed Circle Diameter 20.638 — 50.800 mm

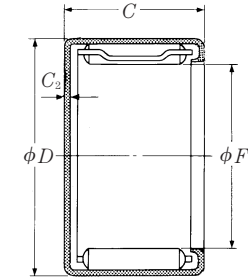


Open Type

$F_w$	Boundary Dimensions (mm, inch)				Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}			
	$D$	$C$ -0.25	$C_2$ max	$C_r$	$P_{max}$					
<b>20.638</b>	0.8125	26.988	1.0625	22.22	0.8750	—	19 400	1 980	12 900	1 320
		28.575	1.1250	19.05	0.7500	1.3	18 900	1 930	11 100	1 130
<b>22.225</b>	0.8750	28.575	1.1250	9.52	0.3750	—	6 600	675	3 300	335
		28.575	1.1250	12.70	0.5000	—	11 000	1 120	6 350	645
	28.575	1.1250	19.05	0.7500	—	17 900	1 830	11 900	1 210	
	28.575	1.1250	25.40	1.0000	1.0	23 800	2 420	17 000	1 730	
	30.162	1.1875	19.05	0.7500	1.3	18 400	1 880	11 000	1 120	
	30.162	1.1875	25.40	1.0000	1.3	25 500	2 600	16 700	1 700	
<b>25.400</b>	1.0000	31.750	1.2500	19.05	0.7500	—	18 200	1 860	12 400	1 270
		31.750	1.2500	25.40	1.0000	1.0	25 000	2 550	18 700	1 910
	33.338	1.3125	19.05	0.7500	1.3	20 800	2 120	13 000	1 330	
	33.338	1.3125	25.40	1.0000	1.3	27 700	2 830	18 900	1 930	
	38.100	1.5000	19.05	0.7500	1.3	23 500	2 390	14 000	1 420	
<b>28.575</b>	1.1250	34.925	1.3750	12.70	0.5000	1.0	11 700	1 200	7 250	740
		34.925	1.3750	19.05	0.7500	1.0	19 100	1 950	13 600	1 380
	34.925	1.3750	25.40	1.0000	1.0	26 200	2 670	20 400	2 080	
	38.100	1.5000	19.05	0.7500	1.3	23 500	2 390	14 000	1 420	
<b>31.750</b>	1.2500	38.100	1.5000	25.40	1.0000	1.3	32 000	3 250	20 700	2 110
		38.100	1.5000	28.58	1.1250	1.3	36 500	3 700	24 600	2 510
	41.275	1.6250	19.05	0.7500	—	19 900	2 030	14 700	1 500	
	41.275	1.6250	25.40	1.0000	1.0	27 400	2 790	22 100	2 250	
	41.275	1.6250	19.05	0.7500	—	24 200	2 470	14 900	1 520	
<b>34.925</b>	1.3750	41.275	1.6250	25.40	1.0000	1.3	34 000	3 500	23 200	2 360
		41.275	1.6250	31.75	1.2500	—	42 500	4 350	31 000	3 150
	44.450	1.7500	12.70	0.5000	1.0	12 400	1 260	8 150	830	
	44.450	1.7500	19.05	0.7500	1.3	26 400	2 690	16 800	1 710	
<b>38.100</b>	1.5000	44.450	1.7500	25.40	1.0000	1.3	36 500	3 750	25 600	2 610
		47.625	1.8750	19.05	0.7500	1.3	28 500	2 900	19 000	1 930
	47.625	1.8750	25.40	1.0000	1.3	39 500	4 000	28 900	2 950	
<b>41.275</b>	1.6250	47.625	1.8750	31.75	1.2500	1.3	49 500	5 050	39 000	3 950
		50.800	2.0000	25.40	1.0000	1.3	39 500	4 000	29 500	3 000
<b>44.450</b>	1.7500	53.975	2.1250	19.05	0.7500	1.3	29 700	3 050	21 000	2 140
		53.975	2.1250	25.40	1.0000	1.3	40 000	4 100	31 000	3 150
	53.975	2.1250	38.10	1.5000	1.3	60 000	6 100	52 000	5 300	
<b>47.625</b>	1.8750	57.150	2.2500	25.40	1.0000	1.3	41 500	4 200	32 000	3 300
		50.800	2.0000	25.40	1.0000	1.3	42 500	4 350	34 500	3 500

Remarks Sealed bearings are available upon the request.

NSK NEEDLE BEARING



Closed Type

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)		Matching Inner Rings	
	Open	Closed		Open	approx Closed			
Oil	J	JH	MJ	MJH				
16 000	<b>J-1314</b>	—	—	—	25	—	—	—
16 000	—	<b>JH-1312</b>	—	<b>MJH-13121</b>	29	31	—	—
14 000	<b>J-146</b>	—	—	—	11	—	—	—
14 000	<b>J-148</b>	—	—	—	16	—	—	—
14 000	<b>J-1412</b>	—	—	—	25	—	<b>IR-1012</b>	—
14 000	<b>J-1416</b>	—	<b>MJ-14161</b>	—	33	36	<b>IR-1016</b>	—
15 000	—	<b>JH-1412</b>	—	<b>MJH-14121</b>	31	36	<b>IR-1012</b>	—
15 000	—	<b>JH-1416</b>	—	<b>MJH-14161</b>	42	47	<b>IR-1016</b>	—
12 000	<b>J-1612</b>	—	—	—	28	—	<b>IR-1212</b>	<b>IR-1312</b>
12 000	<b>J-1616</b>	—	<b>MJ-16161</b>	—	36	40	<b>IR-1216</b>	<b>IR-1316</b>
13 000	—	<b>JH-1612</b>	—	<b>MJH-16121</b>	34	40	<b>IR-1212</b>	<b>IR-1312</b>
13 000	—	<b>JH-1616</b>	—	<b>MJH-16161</b>	46	51	<b>IR-1216</b>	<b>IR-1316</b>
11 000	<b>J-188</b>	—	<b>MJ-1881</b>	—	27	30	—	—
11 000	<b>J-1812</b>	—	<b>MJ-18121</b>	—	30	35	—	—
11 000	<b>J-1816</b>	—	<b>MJ-18161</b>	—	47	51	<b>IR-1416</b>	<b>IR-1516</b>
11 000	—	<b>JH-1812</b>	—	<b>MJH-18121</b>	45	52	—	—
11 000	—	<b>JH-1816</b>	—	<b>MJH-18161</b>	62	69	<b>IR-1416</b>	<b>IR-1516</b>
11 000	—	<b>JH-1818</b>	—	<b>MJH-18181</b>	71	78	—	—
10 000	<b>J-2012</b>	—	<b>MJ-20121</b>	—	43	46	<b>IR-1612</b>	—
10 000	<b>J-2016</b>	—	<b>MJ-20161</b>	—	61	65	<b>IR-1616</b>	—
10 000	—	<b>JH-2012</b>	—	—	66	—	—	—
10 000	—	<b>JH-2016</b>	—	<b>MJH-20161</b>	70	76	<b>IR-1616</b>	—
10 000	—	<b>JH-2020</b>	—	—	75	—	—	—
9 000	<b>J-228</b>	—	<b>MJ-2281</b>	—	68	77	—	—
9 000	—	<b>JH-2212</b>	—	<b>MJH-22121</b>	53	61	<b>IR-1812</b>	—
9 000	—	<b>JH-2216</b>	—	<b>MJH-22161</b>	73	81	<b>IR-1816</b>	—
8 500	<b>J-2412</b>	—	<b>MJ-24121</b>	—	58	68	—	—
8 500	<b>J-2416</b>	—	<b>MJ-24161</b>	—	81	90	<b>IR-1916</b>	<b>IR-2016</b>
8 500	<b>J-2420</b>	—	<b>MJ-24201</b>	—	105	115	<b>IR-1920</b>	<b>IR-2020</b>
7 500	<b>J-2616</b>	—	<b>MJ-26161</b>	—	89	96	—	—
7 100	<b>J-2812</b>	—	<b>MJ-28121</b>	—	91	105	—	—
7 100	<b>J-2816</b>	—	<b>MJ-28161</b>	—	92	105	<b>IR-2316</b>	<b>IR-2426</b>
7 100	<b>J-2824</b>	—	<b>MJ-28241</b>	—	140	155	<b>IR-2324</b>	<b>IR-2424</b>
6 700	<b>J-3016</b>	—	<b>MJ-30161</b>	—	96	135	—	—
6 300	<b>J-3216</b>	—	<b>MJ-32161</b>	—	99	165	—	—

Full Complement Type

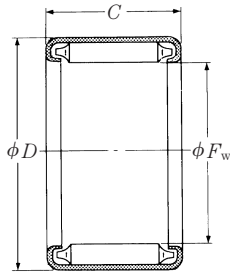
B (Open Type)

BH

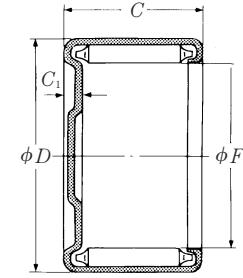
M (Closed Type)

MH

Inscribed Circle Diameter 11.112 — 15.875 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}	
	$D$	$C$ -0.25	$C_1$ max	$C_r$	$P_{max}$					
<b>11.112</b>	0.4375	15.875	0.6250	9.52	0.3750	—	6 050	620	3 900	400
		15.875	0.6250	11.13	—	—	7 350	750	5 000	510
	15.875	0.6250	12.70	0.5000	2.0	8 600	875	6 100	625	
	15.875	0.6250	15.88	0.6250	—	10 900	1 110	8 300	850	
	17.462	0.6875	12.70	0.5000	2.3	9 850	1 000	6 000	610	
	17.462	0.6875	12.70	0.5000	2.0	5 100	520	3 200	325	
<b>12.700</b>	0.5000	17.462	0.6875	7.92	—	—	5 100	520	3 200	325
		17.462	0.6875	9.52	0.3750	2.0	6 550	665	4 400	450
		17.462	0.6875	11.13	—	2.0	7 950	810	5 650	575
	17.462	0.6875	12.70	0.5000	2.0	9 250	945	6 900	700	
	17.462	0.6875	15.88	0.6250	2.0	11 800	1 200	9 350	955	
	17.462	0.6875	19.05	0.7500	2.0	14 100	1 440	11 800	1 210	
<b>14.288</b>	0.5625	19.050	0.7500	11.13	—	—	9 000	920	5 400	550
		19.050	0.7500	12.70	0.5000	2.3	10 700	1 090	6 700	685
		19.050	0.7500	15.88	0.6250	2.3	13 800	1 400	9 350	950
	19.050	0.7500	19.05	0.7500	2.3	16 700	1 700	11 900	1 220	
	19.050	0.7500	7.92	—	2.0	5 400	550	3 550	360	
	19.050	0.7500	9.52	0.3750	2.0	7 000	710	4 900	500	
<b>15.875</b>	0.6250	19.050	0.7500	11.13	—	2.0	8 500	865	6 300	640
		19.050	0.7500	12.70	0.5000	2.0	9 900	1 010	7 650	780
		19.050	0.7500	15.88	0.6250	2.0	12 500	1 280	10 400	1 060
	19.050	0.7500	19.05	0.7500	2.0	15 100	1 540	13 200	1 340	
	20.638	0.8125	12.70	0.5000	—	11 400	1 170	7 400	755	
	20.638	0.8125	15.88	0.6250	—	14 800	1 510	10 300	1 050	
<b>15.875</b>	0.6250	20.638	0.8125	19.05	0.7500	2.3	17 900	1 830	13 200	1 350
		20.638	0.8125	7.92	—	2.0	5 750	585	3 900	395
		20.638	0.8125	11.13	—	2.0	8 950	915	6 900	705
	20.638	0.8125	12.70	0.5000	2.0	10 500	1 070	8 400	860	
	20.638	0.8125	15.88	0.6250	2.0	13 300	1 350	11 400	1 170	
	20.638	0.8125	19.05	0.7500	2.0	16 000	1 630	14 500	1 480	
22.225	0.8750	12.70	0.5000	2.3	12 200	1 240	8 150	830		
22.225	0.8750	15.88	0.6250	—	15 700	1 600	11 300	1 150		
22.225	0.8750	19.05	0.7500	2.3	19 000	1 940	14 500	1 470		
22.225	0.8750	25.40	1.0000	—	25 200	2 570	20 800	2 120		

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)		Matching Inner Rings
	Oil	Open	Closed	Open	Closed		
6 000	B-76	BH-77	M-78	MH-78	5.4	—	—
	B-77	BH-78	M-781	MH-781	6.4	—	—
	B-78	BH-78	M-781	MH-781	7.3	8.2	—
	B-710	BH-78	M-781	MH-781	9.5	—	—
	B-710	BH-78	M-781	MH-781	10	11	—
	5 300	B-85	BH-85	M-851	MH-851	5.4	6.4
5 300	B-86	BH-86	M-861	MH-861	6.4	7.3	—
	B-87	BH-87	M-871	MH-871	7.3	8.2	—
	B-88	BH-88	M-881	MH-881	8.2	9.1	—
	B-810	BH-810	M-8101	MH-8101	11	12	—
	B-812	BH-812	M-8121	MH-8121	13	14	—
	7 500	B-812	BH-812	M-8121	MH-8121	18	19
5 000	B-95	BH-95	M-951	MH-951	5.7	7.1	—
	B-96	BH-96	M-961	MH-961	6.4	7.7	—
	B-97	BH-97	M-971	MH-971	7.7	9.1	—
	B-98	BH-98	M-981	MH-981	9.1	10	IR-68
	B-910	BH-910	M-9101	MH-9101	12	13	—
	B-912	BH-912	M-9121	MH-9121	14	16	IR-612
7 100	B-98	BH-98	M-981	MH-981	12	—	IR-68
	B-910	BH-910	M-9101	MH-9101	16	—	—
	B-912	BH-912	M-9121	MH-9121	20	21	IR-612
	B-105	BH-105	M-1051	MH-1051	5.9	7.7	—
	B-107	BH-107	M-1071	MH-1071	8.6	11	—
	B-108	BH-108	M-1081	MH-1081	10	12	IR-68-1
4 500	B-1010	BH-1010	M-10101	MH-10101	13	15	—
	B-1012	BH-1012	M-10121	MH-10121	16	18	IR-612-1
	B-1012	BH-1012	M-10121	MH-10121	13	15	—
	B-1010	BH-1010	M-10101	MH-10101	17	—	—
	B-1012	BH-1012	M-10121	MH-10121	21	23	IR-612-1
	B-1016	BH-1016	M-10161	MH-10161	30	—	—

Full Complement Type

B (Open Type)

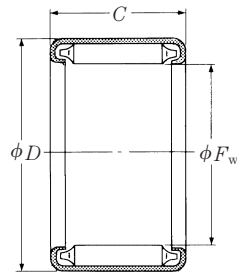
BH

M (Closed Type)

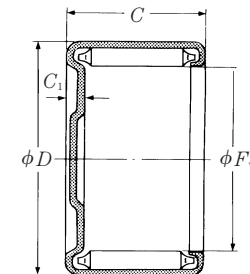
MH

Inscribed Circle

Diameter 17.462 — 23.812 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}	
	$D$		$C_{0-0.25}$	$C_{1max}$	$C_r$	$P_{max}$				
17.462	0.6875	22.225	0.8750	9.52	0.3750	2.0	7 800	795	5 850	600
		22.225	0.8750	12.70	0.5000	2.0	11 000	1 120	9 200	935
		22.225	0.8750	15.88	0.6250	2.0	14 000	1 430	12 500	1 270
	0.7500	22.225	0.8750	19.05	0.7500	2.0	16 800	1 710	15 800	1 610
		23.812	0.9375	11.13	—	—	10 800	1 100	7 100	725
		23.812	0.9375	12.70	0.5000	—	12 800	1 310	8 850	900
		23.812	0.9375	15.88	0.6250	2.3	16 600	1 690	12 300	1 250
		23.812	0.9375	19.05	0.7500	—	20 100	2 050	15 700	1 600
		25.400	1.0000	9.52	0.3750	2.3	9 150	935	5 800	595
		25.400	1.0000	12.70	0.5000	2.3	13 500	1 370	9 550	975
20.638	0.8125	25.400	1.0000	15.88	0.6250	2.3	17 400	1 770	13 300	1 350
		25.400	1.0000	19.05	0.7500	2.3	21 100	2 150	17 000	1 730
		26.988	1.0625	9.52	0.3750	—	9 600	975	6 250	635
	0.8750	26.988	1.0625	12.70	0.5000	2.3	14 100	1 440	10 200	1 050
		26.988	1.0625	22.22	0.8750	2.3	25 700	2 620	22 200	2 270
		26.988	1.0625	25.40	1.0000	2.3	29 200	2 980	26 200	2 670
		28.575	1.1250	12.70	0.5000	2.8	14 100	1 440	9 100	930
		28.575	1.1250	15.88	0.6250	2.8	18 800	1 920	13 200	1 350
		28.575	1.1250	19.05	0.7500	2.8	23 200	2 360	17 300	1 760
		30.162	1.1875	9.52	0.3750	2.3	10 000	1 020	6 700	680
22.225	0.8750	30.162	1.1250	12.70	0.5000	2.3	14 700	1 490	11 000	1 120
		30.162	1.1250	19.05	0.7500	2.3	22 900	2 340	19 500	1 990
		28.575	1.1250	25.40	1.0000	2.3	30 500	3 100	28 000	2 860
	0.9375	28.575	1.1250	28.58	1.1250	—	34 000	3 450	32 500	3 300
		30.162	1.1875	15.88	0.6250	2.8	19 400	1 980	14 100	1 430
		30.162	1.1875	19.05	0.7500	2.8	24 000	2 440	18 400	1 880
		30.162	1.1875	25.40	1.0000	2.8	32 500	3 300	27 100	2 770
		15 200	1 550	11 700	1 190					
		31 500	3 200	29 800	3 050					

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)		Matching Inner Rings
	Open	Closed			Open	Closed	
Oil	B	BH	M	MH			
4 000	<b>B-116</b>		<b>M-1161</b>		10	12	— —
4 000	<b>B-118</b>		<b>M-1181</b>		11	14	— —
4 000	<b>B-1110</b>		<b>M-11101</b>		14	17	— —
4 000	<b>B-1112</b>		<b>M-11121</b>		17	20	— —
6 000		<b>BH-117</b>		—	13	—	— —
6 000		<b>BH-118</b>		—	17	—	— —
6 000		<b>BH-1110</b>		<b>MH-11101</b>	20	23	— —
6 000		<b>BH-1112</b>		—	25	—	— —
5 300	<b>B-126</b>		<b>M-1261</b>		10	13	— —
5 300	<b>B-128</b>		<b>M-1281</b>		15	18	<b>IR-88</b> —
5 300	<b>B-1210</b>		<b>M-12101</b>		20	23	— —
5 300	<b>B-1212</b>		<b>M-12121</b>		25	28	<b>IR-812</b> —
5 000	<b>B-136</b>		—		12	—	— —
5 000	<b>B-138</b>		<b>M-1381</b>		17	20	— —
5 000	<b>B-1314</b>		<b>M-13141</b>		32	36	— —
5 000	<b>B-1316</b>		<b>M-13161</b>		37	40	— —
6 000		<b>BH-138</b>		<b>MH-1381</b>	22	24	— —
6 000		<b>BH-1310</b>		<b>MH-13101</b>	26	29	— —
6 000		<b>BH-1312</b>		<b>MH-13121</b>	35	37	— —
4 800	<b>B-146</b>		<b>M-1461</b>		13	17	— —
4 800	<b>B-148</b>		<b>M-1481</b>		18	22	— —
4 800	<b>B-1412</b>		<b>M-14121</b>		29	33	<b>IR-1012</b> —
4 800	<b>B-1416</b>		<b>M-14161</b>		40	43	<b>IR-1016</b> —
4 800	<b>B-1418</b>		—		50	—	— —
5 600		<b>BH-1410</b>		<b>MH-14101</b>	30	35	— —
5 600		<b>BH-1412</b>		<b>MH-14121</b>	36	41	<b>IR-1012</b> —
5 600		<b>BH-1416</b>		<b>MH-14161</b>	40	43	— —
4 500	<b>B-158</b>		—		20	—	— —
4 500	<b>B-1516</b>		<b>M-15161</b>		41	46	— —

Full Complement Type

B (Open Type)

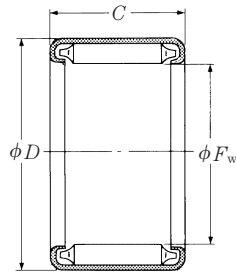
BH

M (Closed Type)

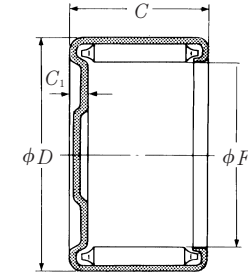
MH

Inscribed Circle

Diameter 25.400 — 31.750 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}			
	$D$	$C$ <sub>-0.25</sub>	$C_1$ <sub>max</sub>	$C_r$	$P_{max}$							
<b>25.400</b>	1.0000	31.750	1.2500	9.52	0.3750	—	10 700	1 090	7 550	770		
		31.750	1.2500	11.13	—	2.3	13 300	1 350	9 950	1 010		
		31.750	1.2500	12.70	0.5000	2.3	15 700	1 610	12 400	1 260		
	1.0625	33.338	1.3125	12.70	0.5000	2.8	15 800	1 610	10 900	1 120		
			1.3125	15.88	0.6250	—	21 000	2 140	15 900	1 620		
			1.3125	19.05	0.7500	2.8	25 900	2 650	20 800	2 120		
		33.338	1.3125	22.22	0.8750	—	30 500	3 100	25 700	2 620		
			1.3125	25.40	1.0000	2.8	35 000	3 600	30 500	3 100		
			1.3125	31.75	1.2500	—	43 500	4 450	40 500	4 100		
		33.338	1.3125	38.10	1.5000	2.8	51 500	5 250	50 500	5 150		
			1.0625	33.338	1.3125	15.88	0.6250	2.3	21 000	2 140	18 200	1 850
				1.1250	34.925	1.3750	9.52	0.3750	2.3	11 400	1 160	8 400
34.925	1.3750	12.70			0.5000	2.3	16 800	1 710	13 800	1 410		
34.925	1.3750	19.05	0.7500		2.3	26 200	2 680	24 500	2 500			
1.1875	38.100	1.5000	25.40	1.0000	2.3	35 000	3 550	35 500	3 600			
		1.5000	19.05	0.7500	3.0	30 000	3 050	22 900	2 340			
		1.5000	25.40	1.0000	3.0	41 000	4 150	34 000	3 500			
	38.100	1.5000	28.58	1.1250	—	46 000	4 700	39 500	4 050			
		1.5000	31.75	1.2500	3.0	51 000	5 200	45 500	4 600			
		1.2500	38.100	1.5000	15.88	0.6250	2.8	23 000	2 350	18 500	1 890	
38.100	1.5000		25.40	1.0000	—	38 500	3 900	35 500	3 650			
1.2500	38.100		1.5000	12.70	0.5000	2.3	17 700	1 810	15 200	1 550		
	38.100	1.5000	15.88	0.6250	2.3	22 900	2 330	21 100	2 150			
	38.100	1.5000	19.05	0.7500	2.3	27 700	2 830	27 000	2 760			
1.2500	38.100	1.5000	25.40	1.0000	2.3	37 000	3 750	39 000	3 950			
		1.5000	31.75	1.2500	2.3	45 500	4 600	50 500	5 150			
		1.6250	12.70	0.5000	3.0	18 400	1 880	12 500	1 280			
	15.05		0.7500	3.0	31 500	3 200	25 000	2 550				
	19.05		1.0000	3.0	43 000	4 400	37 500	3 800				
	31.75	1.2500	3.0	53 500	5 450	49 500	5 050					

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)		Matching Inner Rings	
	Open B	BH	Closed M	MH	Open	approx Closed		
4 000	<b>B-166</b>		—		14	—	—	—
4 000	<b>B-167</b>		<b>M-1671</b>		17	22	—	—
4 000	<b>B-168</b>		<b>M-1681</b>		20	25	<b>IR-128</b>	—
4 000	<b>B-1610</b>		<b>M-16101</b>		26	31	—	—
4 000	<b>B-1612</b>		<b>M-16121</b>		32	37	<b>IR-1212</b>	<b>IR-1312</b>
4 000	<b>B-1616</b>		<b>M-16161</b>		44	49	<b>IR-1216</b>	<b>IR-1316</b>
5 000		<b>BH-168</b>		<b>MH-1681</b>	25	30	<b>IR-128</b>	—
5 000		<b>BH-1610</b>		—	33	—	—	—
5 000		<b>BH-1612</b>		<b>MH-16121</b>	40	45	<b>IR-1212</b>	<b>IR-1312</b>
5 000		<b>BH-1614</b>		—	48	—	—	—
5 000		<b>BH-1616</b>		<b>MH-16161</b>	55	60	<b>IR-1216</b>	<b>IR-1316</b>
5 000		<b>BH-1620</b>		—	70	—	<b>IR-1220</b>	—
5 000		<b>BH-1624</b>		<b>MH-16241</b>	85	91	<b>IR-1224</b>	—
4 000	<b>B-1710</b>		<b>M-17101</b>		27	32	—	—
3 800	<b>B-186</b>		<b>M-1861</b>		15	20	—	—
3 800	<b>B-188</b>		<b>M-1881</b>		23	28	—	—
3 800	<b>B-1812</b>		<b>M-18121</b>		35	40	—	—
3 800	<b>B-1816</b>		<b>M-18161</b>		48	54	<b>IR-1416</b>	<b>IR-1516</b>
5 300		<b>BH-1812</b>		<b>MH-18121</b>	55	62	—	—
5 300		<b>BH-1816</b>		<b>MH-18161</b>	75	82	<b>IR-1416</b>	<b>IR-1516</b>
5 300		<b>BH-1818</b>		—	86	—	—	—
5 300		<b>BH-1820</b>		<b>MH-18201</b>	98	105	—	—
4 300	<b>B-1910</b>		<b>M-19101</b>		35	41	—	—
4 300	<b>B-1916</b>		—		62	—	—	—
3 400	<b>B-208</b>		<b>M-2081</b>		24	31	—	—
3 400	<b>B-2010</b>		<b>M-20101</b>		32	38	—	—
3 400	<b>B-2012</b>		<b>M-20121</b>		39	45	<b>IR-1612</b>	—
3 400	<b>B-2016</b>		<b>M-20161</b>		54	60	<b>IR-1616</b>	—
3 400	<b>B-2020</b>		<b>M-20201</b>		68	74	—	—
5 000		<b>BH-208</b>		<b>MH-2081</b>	28	32	—	—
5 000		<b>BH-2012</b>		<b>MH-20121</b>	57	62	<b>IR-1612</b>	—
5 000		<b>BH-2016</b>		<b>MH-20161</b>	80	86	<b>IR-1616</b>	—
5 000		<b>BH-2020</b>		<b>MH-20201</b>	105	110	—	—



Full Complement Type

B (Open Type)

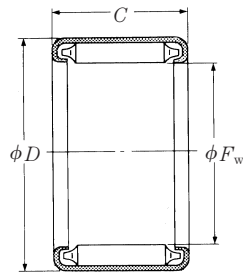
BH

M (Closed Type)

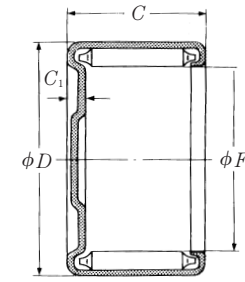
MH

Inscribed Circle

Diameter 33.338 — 50.800 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}	
	$D$		$C$ -0.25	$C_1$ max	$C_r$	$P_{max}$				
<b>33.338</b>	1.3125	41.275	1.6250	12.70	0.5000	2.8	18 300	1 860	14 000	1 430
		41.275	1.6250	15.88	0.6250	2.8	24 400	2 490	20 300	2 070
<b>34.925</b>	1.3750	41.275	1.6250	12.70	0.5000	2.3	18 600	1 900	16 600	1 690
		41.275	1.6250	19.05	0.7500	2.3	29 200	2 970	29 500	3 000
		41.275	1.6250	25.40	1.0000	2.3	38 500	3 950	42 500	4 350
		41.275	1.6250	31.75	1.2500	2.3	47 500	4 850	55 500	5 650
		44.450	1.7500	12.70	0.5000	—	20 100	2 050	14 100	1 440
		44.450	1.7500	15.88	0.6250	—	27 200	2 770	20 800	2 120
		44.450	1.7500	19.05	0.7500	3.0	33 500	3 450	27 500	2 800
		44.450	1.7500	25.40	1.0000	3.0	46 000	4 700	41 000	4 150
<b>38.100</b>	1.5000	44.450	1.7500	31.75	1.2500	—	57 000	5 850	54 000	5 550
		47.625	1.8750	12.70	0.5000	3.0	20 900	2 130	15 200	1 550
		47.625	1.8750	15.88	0.6250	3.0	38 200	2 880	22 500	2 290
		47.625	1.8750	19.05	0.7500	3.0	35 000	3 600	29 700	3 050
		47.625	1.8750	22.22	0.8750	3.0	41 500	4 250	37 000	3 750
		47.625	1.8750	25.40	1.0000	3.0	48 000	4 850	44 000	4 500
		47.625	1.8750	31.75	1.2500	3.0	59 500	6 050	58 500	6 000
		47.625	1.8750	31.75	1.2500	3.0	59 500	6 050	58 500	6 000
<b>41.275</b>	1.6250	50.800	2.0000	12.70	0.5000	—	21 500	2 200	16 200	1 660
		50.800	2.0000	15.88	0.6250	3.0	29 200	2 980	24 000	2 450
		50.800	2.0000	25.40	1.0000	—	49 500	5 050	47 500	4 850
		50.800	2.0000	31.75	1.2500	3.0	61 500	6 300	63 000	6 400
<b>44.450</b>	1.7500	53.975	2.1250	19.05	0.7500	3.0	37 500	3 850	34 000	3 450
		53.975	2.1250	25.40	1.0000	3.0	51 000	5 250	50 500	5 150
		53.975	2.1250	31.75	1.2500	—	64 000	6 500	67 500	6 850
		53.975	2.1250	38.10	1.5000	3.0	76 000	7 750	84 000	8 550
<b>47.625</b>	1.8750	57.150	2.2500	12.70	0.5000	3.0	23 500	2 400	18 700	1 910
		57.150	2.2500	19.05	0.7500	—	39 500	4 050	36 500	3 700
		57.150	2.2500	25.40	1.0000	3.0	54 000	5 500	54 000	5 550
<b>50.800</b>	2.0000	60.325	2.3750	12.70	0.5000	3.0	24 000	2 450	19 700	2 010
		60.325	2.3750	25.40	1.0000	3.0	55 000	5 650	57 500	5 850
		60.325	2.3750	31.75	1.2500	3.0	69 000	7 000	76 000	7 750
		60.325	2.3750	38.10	1.5000	3.0	82 000	8 350	95 000	9 700
		60.325	2.3750	44.45	1.7500	3.0	94 000	9 600	114 000	11 600
		60.325	2.3750	44.45	1.7500	3.0	94 000	9 600	114 000	11 600

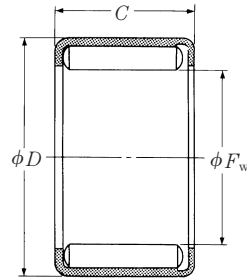
Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)		Matching Inner Rings	
	Open		Closed		Open	Closed		
Oil	B	BH	M	MH	approx			
4 000	<b>B-218</b>		<b>M-2181</b>		32	38	—	—
	<b>B-2110</b>		<b>M-21101</b>		40	46	—	—
3 000	<b>B-228</b>		<b>M-2281</b>		27	34	—	—
	<b>B-2212</b>		<b>M-22121</b>		43	49	<b>IR-1812</b>	—
	<b>B-2216</b>		<b>M-22161</b>		58	65	<b>IR-1816</b>	—
4 500	<b>B-2220</b>		<b>M-22201</b>		74	83	<b>IR-1820</b>	—
		<b>BH-228</b>		—	29	—	—	—
		<b>BH-2210</b>		—	43	—	—	—
4 500		<b>BH-2212</b>		<b>MH-22121</b>	58	66	<b>IR-1812</b>	—
		<b>BH-2216</b>		<b>MH-22161</b>	87	95	<b>IR-1816</b>	—
		<b>BH-2220</b>		—	115	—	<b>IR-1820</b>	—
4 000	<b>B-248</b>		<b>M-2481</b>		39	48	—	—
	<b>B-2410</b>		<b>M-24101</b>		54	63	—	—
	<b>B-2412</b>		<b>M-24121</b>		69	78	—	—
4 000	<b>B-2414</b>		<b>M-24141</b>		81	90	—	—
	<b>B-2416</b>		<b>M-24161</b>		92	100	<b>IR-1916</b>	<b>IR-2016</b>
	<b>B-2420</b>		<b>M-24201</b>		120	130	<b>IR-1920</b>	<b>IR-2020</b>
3 800	<b>B-268</b>		—		40	—	—	—
	<b>B-2610</b>		<b>M-26101</b>		57	74	—	—
	<b>B-2616</b>		—		89	—	—	—
	<b>B-2620</b>		<b>M-26201</b>		140	155	<b>IR-2220</b>	—
3 600	<b>B-2812</b>		<b>M-28121</b>		78	92	—	—
	<b>B-2816</b>		<b>M-28161</b>		110	125	<b>IR-2316</b>	<b>IR-2416</b>
	<b>B-2820</b>		—		140	—	—	—
	<b>B-2824</b>		<b>M-28241</b>		170	190	<b>IR-2324</b>	<b>IR-2424</b>
3 400	<b>B-308</b>		<b>M-3081</b>		52	73	—	—
	<b>B-3012</b>		—		82	—	—	—
	<b>B-3016</b>		<b>M-30161</b>		110	130	—	—
3 200	<b>B-328</b>		<b>M-3281</b>		51	72	—	—
	<b>B-3216</b>		<b>M-32161</b>		120	140	—	—
	<b>B-3220</b>		<b>M-32201</b>		150	175	—	—
3 200	<b>B-3224</b>		<b>M-32241</b>		185	205	—	—
	<b>B-3228</b>		<b>M-32281</b>		220	240	—	—

Full Complement Type (Grease-Retained Roller Type)

Y

YH

Inscribed Circle Diameter 3.969 — 20.638 mm



$F_w$	Boundary Dimensions (mm, inch)				Basic Dynamic Load Ratings (N) {kgf}		
	$D$		$C$ <small>0.025</small>		$C_r$		
<b>3.969</b>	—	7.144	—	3.96	—	1 260	129
	—	7.144	—	6.35	0.2500	2 300	235
<b>4.762</b>	0.1875	8.731	—	6.35	0.2500	2 560	261
<b>6.350</b>	0.2500	11.112	0.4375	7.92	—	4 150	420
		11.112	0.4375	11.13	—	5 950	605
<b>7.938</b>	0.3125	12.700	0.5000	7.92	—	4 750	485
<b>9.525</b>	0.3750	14.288	0.5625	6.35	0.2500	4 000	410
		14.288	0.5625	9.52	0.3750	6 500	660
		14.288	0.5625	12.70	0.5000	8 750	890
		14.288	0.5625	15.88	0.6250	10 800	1 100
<b>11.112</b>	0.4375	15.875	0.6250	12.70	0.5000	9 550	975
		17.462	0.6875	12.70	0.5000	11 400	1 160
<b>12.700</b>	0.5000	17.462	0.6875	6.35	0.2500	4 700	480
		17.462	0.6875	9.52	0.3750	7 650	780
		17.462	0.6875	11.13	—	9 000	915
		17.462	0.6875	12.70	0.5000	10 300	1 050
		17.462	0.6875	15.88	0.6250	12 700	1 300
		17.462	0.6875	19.05	0.7500	15 000	1 530
		19.050	0.7500	15.88	0.6250	14 600	1 480
		19.050	0.7500	12.70	0.5000	11 000	1 120
		19.050	0.7500	15.88	0.6250	13 600	1 380
		19.050	0.7500	19.05	0.7500	16 000	1 640
<b>14.288</b>	0.5625	19.050	0.7500	12.70	0.5000	11 000	1 120
		19.050	0.7500	15.88	0.6250	13 600	1 380
		19.050	0.7500	19.05	0.7500	16 000	1 640
		19.050	0.7500	12.70	0.5000	11 000	1 120
<b>15.875</b>	0.6250	20.638	0.8125	7.92	—	7 050	720
		20.638	0.8125	12.70	0.5000	11 600	1 180
		20.638	0.8125	19.05	0.7500	17 000	1 730
		22.225	0.8750	12.70	0.5000	13 300	1 360
<b>17.462</b>	0.6875	22.225	0.8750	19.05	0.7500	17 900	1 820
<b>19.050</b>	0.7500	25.400	1.0000	6.35	0.2500	6 250	640
		25.400	1.0000	12.70	0.5000	10 800	1 100
		25.400	1.0000	15.88	0.6250	18 600	1 890
		25.400	1.0000	19.05	0.7500	22 100	2 250
<b>20.638</b>	0.8125	26.988	1.0625	9.52	0.3750	11 300	1 150
		26.988	1.0625	12.70	0.5000	15 500	1 580
		28.575	1.1250	15.88	0.6250	21 300	2 170
		28.575	1.1250	19.05	0.7500	25 600	2 610

Limiting Loads		Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers	Mass (g)  approx
(N)	{kgf}			
$P_{max}$		Oil		
580	59	10 000	<b>Y-2</b> 1/22 1/2	0.4
1 260	128	10 000		<b>Y-2</b> 1/24
1 350	137	10 000	<b>Y-34</b>	2.3
2 300	234	10 000	<b>Y-45</b>	3.2
3 700	375	10 000		<b>Y-47</b>
2 760	281	8 000	<b>Y-55</b>	4.1
2 250	229	7 100	<b>Y-64</b>	3.2
4 200	425	7 100		<b>Y-66</b>
6 100	625	7 100	<b>Y-68</b>	7.3
8 050	820	7 100		<b>Y-610</b>
7 000	715	6 000	<b>Y-78</b>	8.2
7 250	740	8 500		<b>YH-78</b>
2 890	295	5 300	<b>Y-84</b>	5.4
5 350	550	5 300		<b>Y-86</b>
6 600	675	5 300	<b>Y-87</b>	8.2
7 850	800	5 300		<b>Y-88</b>
10 300	1 050	5 300	<b>Y-810</b>	11
12 800	1 310	5 300		<b>Y-812</b>
10 300	1 050	7 500	<b>YH-810</b>	16
8 750	890	5 000		<b>Y-98</b>
11 500	1 170	5 000	<b>Y-910</b>	12
14 200	1 450	5 000		<b>Y-912</b>
5 050	515	4 500	<b>Y-105</b>	6.4
9 600	980	4 500		<b>Y-108</b>
15 700	1 600	4 500	<b>Y-1012</b>	17
9 350	955	6 000		<b>YH-108</b>
17 100	1 740	4 000	<b>Y-1112</b>	24
3 650	370	5 300	<b>Y-124</b>	8.2
7 350	750	5 300		<b>Y-128</b>
14 700	1 500	5 300	<b>Y-1210</b>	22
18 400	1 880	5 300		<b>Y-1212</b>
7 900	805	5 000	<b>Y-136</b>	13
11 900	1 210	5 000		<b>Y-138</b>
15 500	1 580	6 000	<b>YH-1310</b>	28
19 600	2 000	6 000		<b>YH-1312</b>

Remarks 1. In this type of bearing, a special grease holds the rollers in place until mounting.  
2. Metric series bearings are available. Please consult NSK.

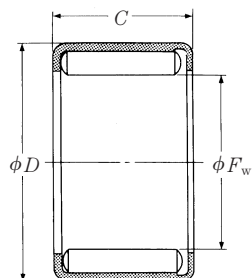
Full Complement Type (Grease-Retained Roller Type)

Y

YH

Inscribed Circle

Diameter 22.225 — 47.625 mm



$F_w$	Boundary Dimensions (mm, inch)				Basic Dynamic Load Ratings (N) {kgf}		
	$D$		$C$ <sub>-0.25</sub>		$C_r$		
<b>22.225</b>	0.8750	28.575	1.1250	12.70	0.5000	15 900	1 620
		28.575	1.1250	19.05	0.7500	23 700	2 410
		28.575	1.1250	25.40	1.0000	31 000	3 150
		30.162	1.1875	19.05	0.7500	25 500	2 600
<b>25.400</b>	1.0000	31.750	1.2500	12.70	0.5000	17 200	1 750
		31.750	1.2500	19.05	0.7500	25 500	2 600
		31.750	1.2500	25.40	1.0000	33 000	3 400
		33.338	1.3125	12.70	0.5000	18 800	1 920
		33.338	1.3125	19.05	0.7500	28 600	2 920
<b>28.575</b>	1.1250	34.925	1.3750	12.70	0.5000	18 300	1 870
		34.925	1.3750	19.05	0.7500	27 200	2 780
		34.925	1.3750	25.40	1.0000	35 500	3 600
<b>30.162</b>	1.1875	38.100	1.5000	15.88	0.6250	26 500	2 700
<b>31.750</b>	1.2500	38.100	1.5000	15.88	0.6250	24 300	2 480
		38.100	1.5000	19.05	0.7500	28 900	2 940
		38.100	1.5000	25.40	1.0000	37 500	3 850
<b>34.925</b>	1.3750	38.100	1.5000	28.58	1.1250	41 500	4 250
		38.100	1.5000	31.75	1.2500	45 500	4 650
		41.275	1.6250	12.70	0.5000	20 000	2 040
		41.275	1.6250	19.05	0.7500	29 700	3 050
<b>38.100</b>	1.5000	41.275	1.6250	31.75	1.2500	47 000	4 800
		47.625	1.8750	9.52	0.3750	16 900	1 730
		47.625	1.8750	12.70	0.5000	24 700	2 520
		47.625	1.8750	22.22	0.8750	44 500	4 550
		47.625	1.8750	25.40	1.0000	51 000	5 200
<b>41.275</b>	1.6250	47.625	1.8750	31.75	1.2500	62 500	6 350
		50.800	2.0000	15.88	0.6250	33 000	3 350
<b>44.450</b>	1.7500	53.975	2.1250	25.40	1.0000	54 500	5 550
<b>47.625</b>	1.8750	57.150	2.2500	19.05	0.7500	43 000	4 400

Limiting Loads		Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers	Mass (g) approx
(N)	{kgf}			
$P_{max}$		Oil		
12 700	1 290	4 500	<b>Y-148</b>	20
21 100	2 150	4 500	<b>Y-1412</b>	31
29 600	3 000	4 500	<b>Y-1416</b>	42
20 500	2 090	5 300	<b>YH-1412</b>	38
14 300	1 460	4 000	<b>Y-168</b>	23
23 900	2 430	4 000	<b>Y-1612</b>	35
33 500	3 400	4 000	<b>Y-1616</b>	47
13 800	1 400	5 000	<b>YH-168</b>	30
23 600	2 410	5 000	<b>YH-1612</b>	43
33 500	3 400	5 000	<b>YH-1616</b>	58
16 000	1 630	3 600	<b>Y-188</b>	26
26 600	2 710	3 600	<b>Y-1812</b>	38
37 500	3 800	3 600	<b>Y-1816</b>	52
22 200	2 260	4 300	<b>Y-1910</b>	43
23 500	2 400	3 200	<b>Y-2010</b>	34
29 300	2 990	3 200	<b>Y-2012</b>	42
41 000	4 200	3 200	<b>Y-2016</b>	57
47 000	4 800	3 200	<b>Y-2018</b>	64
53 000	5 400	3 200	<b>Y-2020</b>	72
19 300	1 960	2 800	<b>Y-228</b>	36
32 000	3 250	2 800	<b>Y-2212</b>	47
58 000	5 900	2 800	<b>Y-2220</b>	76
11 600	1 190	4 000	<b>Y-246</b>	34
18 900	1 930	4 000	<b>Y-248</b>	48
40 500	4 150	4 000	<b>Y-2414</b>	89
48 000	4 850	4 000	<b>Y-2416</b>	100
62 000	6 350	4 000	<b>Y-2420</b>	125
27 900	2 840	3 800	<b>Y-2610</b>	73
55 000	5 600	3 600	<b>Y-2816</b>	120
41 000	4 200	3 400	<b>Y-3012</b>	115

Remarks 1. In this type of bearing, a special grease holds the rollers in place until mounting.  
2. Metric series bearings are available. Please consult NSK.

Miniature Bearings with Cages

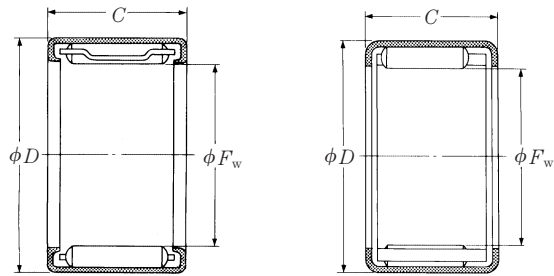
FJ • FJH • FJL (Open Type)

FJP

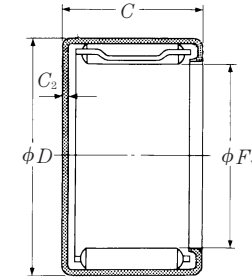
MFJ • MFJH (Closed Type)

MFJL

Inscribed Circle Diameter 3 — 9 mm



Open Type



Closed Type

FJ, FJH, FJL

FJP

F <sub>w</sub>	Boundary Dimensions (mm)			Basic Dynamic Load Ratings		Limiting Loads		Limiting Speeds (min <sup>-1</sup> ) Oil
	D	C 0 -0.25	C <sub>2</sub> max	(N)	{kgf}	(N)	{kgf}	
				C <sub>r</sub>		P <sub>max</sub>		
<b>3</b>	6.5	6	—	1 230	125	465	47	100 000
<b>4</b>	8	8	—	1 720	175	670	69	75 000
<b>5</b>	9	8	—	1 550	158	585	60	71 000
	9	9	0.8	1 860	190	745	76	71 000
<b>6</b>	10	9	0.8	2 320	237	985	101	56 000
	<b>7</b>	11	9	2 550	260	1 110	113	48 000
<b>8</b>	12	8	—	2 580	263	1 150	118	40 000
	12	10	0.8	2 840	289	1 270	130	43 000
	14	10	1	4 300	435	1 770	180	45 000
	15	10	1	4 400	450	1 770	181	45 000
	15	15	1	7 100	720	3 250	330	45 000
15	20	1	10 100	1 020	5 100	520	45 000	
<b>9</b>	13	10	0.8	3 300	335	1 600	163	36 000
	15	10	1	4 550	465	1 910	194	40 000
	16	12	1	5 150	525	2 140	219	40 000
	16	16	1	7 800	795	3 650	370	40 000

Bearing Numbers					Mass (g)	
Open		FJL	Closed		approx	Closed
FJP, FJ FJH	MFJ MFJH		MFJL			
<b>* FJP-36</b>	—				0.9	—
<b>* FJP-48</b>	—				1.3	—
<b>FJ-58L</b>	—				1.6	—
<b>FJ-59</b>			<b>MFJ-59</b>		1.7	1.9
<b>FJ-69</b>			<b>MFJ-69</b>		2.2	2.4
<b>FJ-79</b>			<b>MFJ-79</b>		2.3	2.7
<b>FJ-88-2</b>			—		2.3	—
<b>FJ-810</b>			<b>MFJ-810</b>		2.7	3.2
<b>FJH-810</b>			<b>MFJH-810</b>		5.2	5.5
		<b>FJL-810</b>		<b>MFJL-810L</b>	6.0	6.6
		<b>FJL-815</b>		<b>MFJL-815L</b>	8.9	9.9
		<b>FJL-820</b>		<b>MFJL-820L</b>	15	13
<b>FJ-910</b>			<b>MFJ-910</b>		3.2	3.6
<b>FJH-910</b>			<b>MFJH-910</b>		5.7	6.1
		<b>FJL-912L</b>		<b>MFJL-912L</b>	7.7	8.5
		<b>FJL-916</b>		<b>MFJL-916L</b>	11	12

\* These bearings have polyamide cages. The maximum permissible operating temperature for these bearings is 100°C for continued operation and 120°C for short periods.

Full Complement Miniature Bearings

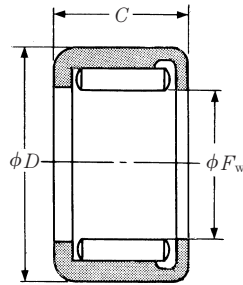
F (Open Type)

MF (Closed Type)

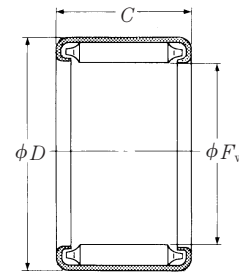
MFY

DD (Open Type • Closed Type)

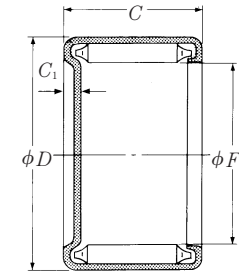
Inscribed Circle Diameter 3.036 — 9 mm



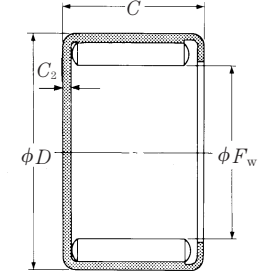
Open Type  
DD



Open Type  
F



MF



Closed Type

MFY, DD

$F_w$	Boundary Dimensions (mm)			Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}	
	$D$	$C$ -0.25	$C_1, C_2$ max	$C_r$	$P_{max}$		
<b>3.036</b>	7.035	6.65	—	1 630	167	855	87
	7.035	9.2	—	2 330	238	1 360	138
<b>4</b>	8	6	0.8	2 240	229	1 150	117
	8	8	1.7	2 470	252	1 300	132
<b>5</b>	9	8	1.7	2 790	285	1 520	155
	9	7	0.8	3 000	305	1 670	170
	9	9	1.7	3 250	335	1 860	190
<b>6</b>	10	8	1.7	3 150	325	1 780	181
	10	9	1.7	3 700	380	2 170	221
<b>7</b>	11	7.5	0.8	4 100	420	2 480	253
	11	9	1.7	4 100	420	2 480	253
<b>8</b>	12	8	1.7	3 850	390	2 280	233
	12	8	0.8	4 750	485	2 990	305
	12	10	1.7	5 000	510	3 200	325
	12	12	1.7	6 200	635	4 200	430
<b>9</b>	13	9	0.8	5 650	575	3 850	395
	13	10	1.7	5 400	550	3 650	370

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers		Mass (g)	
	Open F, DD	Closed MF, MFY, DD	Open approx	Closed
Oil				
12 000	<b>DD500302</b>	—	1.4	—
12 000	<b>DD500304</b>	—	2.0	—
12 000	—	<b>DD500401</b>	—	1.5
12 000	<b>F-48</b>	<b>MF-48</b>	1.4	1.8
10 000	<b>F-58</b>	<b>MF-58</b>	1.8	2.2
10 000	—	<b>MFY-57</b>	—	2.1
10 000	<b>F-59</b>	<b>MF-59</b>	2.0	2.3
8 500	<b>F-68</b>	<b>MF-68</b>	2.1	2.7
8 500	<b>F-69</b>	<b>MF-69</b>	2.3	2.8
7 500	—	<b>DD500701</b>	—	2.8
7 500	<b>F-79</b>	<b>MF-79</b>	2.7	3.2
7 100	<b>F-88</b>	<b>MF-88</b>	2.7	3.2
7 100	—	<b>MFY-88</b>	—	3.3
7 100	<b>F-810</b>	<b>MF-810</b>	3.6	4.1
7 100	<b>F-812</b>	<b>MF-812</b>	3.8	4.7
6 000	—	<b>MFY-99</b>	—	4.1
6 000	<b>F-910</b>	<b>MF-910</b>	4.1	4.5

Miniature Bearings with Cages

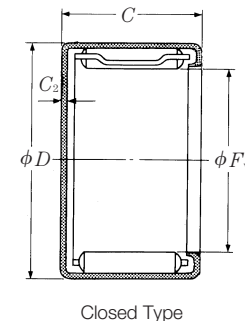
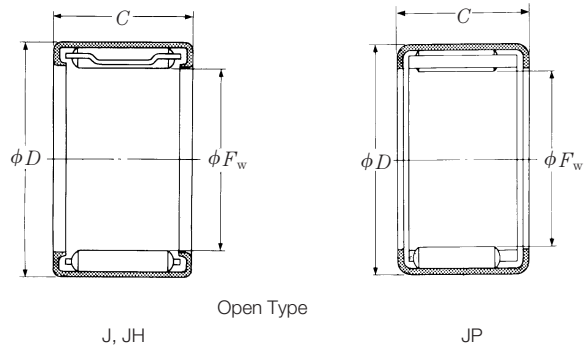
J • JP (Open Type)

JH

MJ • MJH (Closed Type)

Inscribed Circle

Diameter 3.175 — 9.525 mm



$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}	
	$D$	$C$ -0.25	$C_2$ max	$C_r$				
<b>3.175</b>	0.1250	6.350	0.2500	4.78	—	—	890	91
<b>3.969</b>	—	7.144	—	4.78	—	—	910	93
<b>4.762</b>	0.1875	8.731	—	4.78	—	—	1 090	111
		8.731	—	9.52	0.3750	1.0	2 290	234
<b>6.350</b>	0.2500	11.112	0.4375	6.35	0.2500	—	2 040	208
		11.112	0.4375	7.92	—	1.0	1 940	198
		11.112	0.4375	11.13	—	1.0	3 300	335
<b>7.938</b>	0.3125	12.700	0.5000	7.92	—	1.0	2 300	235
		12.700	0.5000	11.13	—	1.0	3 900	400
		14.288	0.5625	11.13	—	1.0	4 700	480
<b>9.525</b>	0.3750	14.288	0.5625	7.92	—	1.0	2 620	267
		14.288	0.5625	12.70	0.5000	1.0	5 250	535

Limiting Loads		Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers		Mass (g)	
(N)	{kgf}		Open J, JP, JH	Closed MJ, MJH	Open	approx Closed
$P_{max}$		Oil				
320	32	75 000	<b>* JP-23-FV</b>	—	0.5	—
320	32	75 000	<b>* JP-2 1/2 3-FV</b>	—	0.5	—
370	38	75 000	<b>* JP-33-FV</b>	—	0.9	—
970	99	75 000	<b>J-36</b>	<b>MJ-361</b>	2.3	2.7
775	79	56 000	<b>* JP-44-FV</b>	—	1.8	—
720	74	56 000	<b>J-45</b>	<b>MJ-451</b>	2.3	2.7
1 430	146	56 000	<b>J-47</b>	<b>MJ-471</b>	3.6	4.1
900	92	43 000	<b>J-55</b>	<b>MJ-551</b>	3.0	3.3
1 790	183	43 000	<b>J-57</b>	<b>MJ-571</b>	4.1	4.5
1 950	199	45 000	<b>JH-57</b>	<b>MJH-571</b>	5.9	6.4
1 080	110	36 000	<b>J-65</b>	<b>MJ-651</b>	3.2	3.6
2 640	270	36 000	<b>J-68</b>	<b>MJ-681</b>	5.4	5.9

\* These bearings have polyamide cages. The maximum permissible operating temperature for these bearings is 100°C for continued operation and 120°C for short periods.

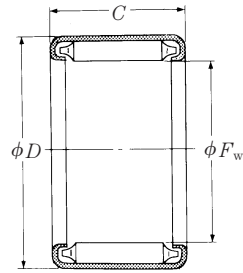
Full Complement Miniature Bearings

B • BH (Open Type)

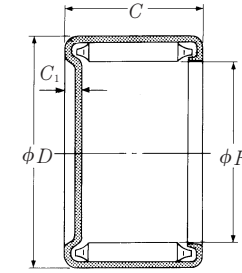
M • MH (Closed Type)

Inscribed Circle

Diameter 3.175 — 9.525 mm



Open Type



Closed Type

$F_w$	Boundary Dimensions (mm, inch)						Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}	
	$D$		$C$ -0.25		$C_1$ max		$C_r$		$P_{max}$	
<b>3.175</b>	0.1250	6.350	0.2500	6.35	0.2500	1.3	1 640	167	835	85
	<b>3.969</b>	—	7.144	—	6.35	0.2500	1.3	1 930	197	1 000
			7.144	—	7.92	—	1.3	2 520	257	1 420
<b>4.762</b>	0.1875	8.731	—	6.35	0.2500	1.8	2 100	214	1 040	106
		8.731	—	9.52	0.3750	1.8	3 600	365	2 090	213
<b>6.350</b>	0.2500	11.112	0.4375	6.35	0.2500	2.0	2 490	254	1 200	122
		11.112	0.4375	7.92	—	2.0	3 350	345	1 760	180
		11.112	0.4375	9.52	0.3750	2.0	4 350	440	2 440	249
		11.112	0.4375	11.13	—	2.0	5 250	535	3 150	320
<b>7.938</b>	0.3125	12.700	0.5000	7.92	—	2.0	3 850	395	2 120	216
		12.700	0.5000	9.52	0.3750	2.0	5 000	510	2 930	299
		12.700	0.5000	11.13	—	2.0	6 050	615	3 750	385
		12.700	0.5000	14.27	—	2.0	8 050	820	5 400	555
		14.288	0.5625	11.13	—	2.3	6 650	680	3 700	375
<b>9.525</b>	0.3750	14.288	0.5625	7.92	—	2.0	4 300	440	2 470	252
		14.288	0.5625	9.52	0.3750	2.0	5 550	565	3 400	350
		14.288	0.5625	11.13	—	—	6 750	690	4 400	450
		14.288	0.5625	12.70	0.5000	2.0	7 850	800	5 350	545
		14.288	0.5625	14.27	—	—	8 950	915	6 300	645
		14.288	0.5625	15.88	0.6250	2.0	10 000	1 020	7 300	740
		15.875	0.6250	12.70	0.5000	2.3	8 950	910	5 300	540

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers				Mass (g)	
	Open		Closed		approx	
	B	BH	M	MH	Open	Closed
12 000	<b>B-24</b>		<b>M-241</b>		0.9	1.4
10 000	<b>B-2 1/2 4</b> <b>B-2 1/2 5</b>		<b>M-2 1/2 41</b> <b>M-2 1/2 51</b>		0.9	1.4
10 000					1.4	1.8
10 000	<b>B-34</b> <b>B-36</b>		<b>M-341</b> <b>M-361</b>		1.8	2.3
10 000					2.3	2.7
10 000	<b>B-44</b> <b>B-45</b> <b>B-46</b> <b>B-47</b>		<b>M-441</b> <b>M-451</b> <b>MC-461</b> <b>M-471</b>		2.3	2.7
10 000					2.7	3.2
10 000					3.4	3.9
10 000					4.1	4.5
8 000	<b>B-55</b> <b>B-56</b> <b>B-57</b>		<b>M-551</b> <b>M-561</b> <b>M-571</b>		3.6	4.1
8 000					4.5	4.8
8 000					5.0	5.4
8 000	<b>B-59</b>		<b>M-591</b>		6.4	6.8
11 000		<b>BH-57</b>			<b>MH-571</b>	6.4
7 100	<b>B-65</b> <b>B-66</b> <b>B-67</b>		<b>M-651</b> <b>M-661</b> —		4.1	4.5
7 100					5.0	5.4
7 100					5.9	—
7 100	<b>B-68</b> <b>B-69</b> <b>B-610</b>		<b>M-681</b> — <b>M-6101</b>		6.8	7.3
7 100					7.7	—
7 100					8.6	9.1
10 000		<b>BH-68</b>		<b>MH-681</b>	9.1	9.5

**SOLID NEEDLE ROLLER BEARINGS**

**METRIC DESIGN**

Pages

RLM · LM, RNA · NA	Inscribed Circle Diameter	8–115 mm .....	B 96–B109
RNA · NA	Inscribed Circle Diameter	120–490 mm .....	B110–B113
RNAF · NAF, RNAFW · NAFW	Inscribed Circle Diameter	10–100 mm .....	B114–B117
RNA··TT, NA··TT	Inscribed Circle Diameter	14–125 mm .....	B118–B121

**INCH DESIGN**

HJ, HJ+IR	Inscribed Circle Diameter	15.875–234.950 mm .....	B122–B127
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Solid needle roller bearings are high-accuracy bearings with maximum load capacity within a limited space for various operating conditions.

Made of carefully selected vacuum-degassed bearing steel or carburizing steel, the raceway rings are finished with accurate grinding after heat treatment. The outer rings have strong integrated ribs and contain high-accuracy rollers that have the proper crowning finish. Lightweight and extremely strong, the cage guides the rollers accurately and smoothly.

**DESIGN AND TYPES**

Solid needle roller bearings come in various types ranging from the light to heavy load use of the metric bearings to heavy load use of inch bearings. Each type is available in series with and without an inner ring, and both series are shown in the same bearing table. Types of solid needle roller bearings are shown in **Table 1**, while the composition of bearing numbers is shown in **Table 2**.

Among NSK solid needle roller bearings, the RNA, NA49, 59, 69 and 48 series follow the international dimension system that conforms to ISO standards.

HJ, HJ + IR series of inch bearings are widely used globally and conform to the **MIL** standards of the U.S.A.

RLM and LM types are bearings whose section height is close to that of drawn cup needle bearings.





RNAF and NAF are different from other solid bearings in that they have a separable inner ring, outer ring, and cage and rollers, which can all be combined to allow the optional radial internal clearance to be chosen. For most operating conditions, they can be easily mounted.

Bearings with seals are also manufactured; please consult NSK.

Typical structure and features of solid needle roller bearings are shown in Fig. 1.

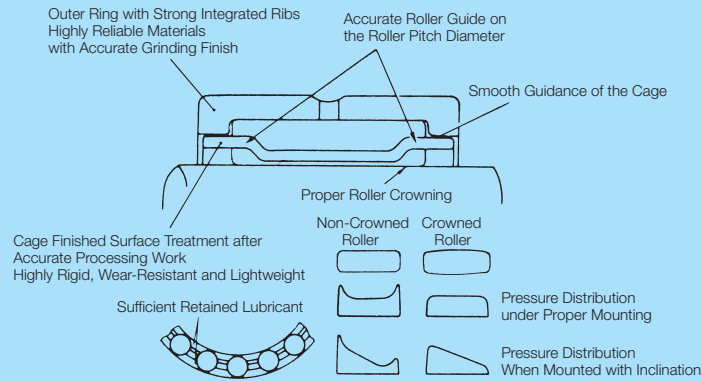


Fig. 1 Features of Solid Needle Roller Bearings

Table 1 Bearing Types

Series	Bearing Code		Shaft Diameter (mm)	Description
	Without Inner Ring	With Inner Ring		
Metric	RLM		8 to 110	Single-row, section height less than or equal to dimensional series 49, for light loads
		LM	5 to 90	
	RNA49		8 to 490	Single-row, dimensional series 49, for normal loads
		NA49	8 to 440	
	RNA59		20 to 160	Single-row, dimensional series 59, same section height as series 49 with wider width, for heavy loads
		NA59	15 to 140	
	RNA69		16 to 110	Single-row, dimensional series 69, same section height as series 49, wider than series 59, for heavy loads
		NA69	12 to 95	
	RNA48		120 to 415	Single-row, dimensional series 48, smaller section height than series 49, for light to normal loads
		NA48	110 to 380	
	RNAF, RNAFW		10 to 100	Single or double-row, separate type, for normal to heavy loads
		NAF, FAFW	10 to 90	
	RNA...TT	NA ... TT	10 to 120	
Inch	HJ		15.875 to 234.950	Single-row, section height slightly greater, with wider width series, for heavy loads
		HJ + IR	9.525 to 203.200	

Table 2 Bearing Numbers for Solid Needle Roller Bearings

Type Code		Composition of Bearing Number	Examples
Without Inner Ring	With Inner Ring		
RLM		Type code, inscribed circle diameter, and width or code, inscribed circle diameter, outside diameter, and width (expressed in mm)	RLM2520, RLM304020
	LM		LM2520, LM304020
RNA		Type code, dimension series, and bore number (48, 49, 59, 69) (00 - 88)	RNA4905, RNA6908, RNA4830
	NA		NA4905, NA6908, NA4830
RNAF		Type code, inscribed circle diameter, outside diameter, and width (expressed in mm)	RNAF253517
	NAF	Type code, bore diameter, outside diameter, and width (expressed in mm)	NAF203517
HJ		Type code, hyphen, inscribed circle diameter, outside diameter, and width (expressed in integers in units of 1/16 inch)	HJ-243316
	HJ + IR	Following HJ bearing number, + inner ring code, hyphen, bore diameter, inner ring raceway diameter, and width (expressed in integers in units of 1/16 inch)	HJ-243316+IR-202416

Remarks For full complement RLM, LM, RNA and NA, the letter "V" is followed by the bearing number.

ACCURACY

All NSK solid needle roller bearings, excluding inch bearings HJ and HJ + IR, conform to ISO, and dimensional accuracy and rotating accuracy are in accordance with ISO (refer to pages A26 and A27). When highly accurate bearings are especially required, bearings in Class 6 or higher are also available.

Tolerance values for inch bearings HJ and HJ + IR are shown in Table 3.

Tolerances for inscribed Circle Diameter

NSK metric needle roller bearings are primarily manufactured within the inscribed circle diameter tolerance class F6 (refer to Table 4 on page B92). RLM and LM types that have a small section height, however, are within F7. Tolerances for the inscribed circle diameter of inch needle bearings are shown in Table 5 on page B93.

**Table 3 Tolerances for Inch Bearings HJ, HJ + IR**

Units:  $\mu\text{m}$

Nominal Bore Diameter, $d$ , or Nominal Outside Diameter, $D$ (mm)		Single Plane Mean Bore Diameter Deviation, $\Delta d_{mp}$		Single Plane Mean Outside Diameter Deviation, $\Delta D_{mp}$		Inner Ring Width Deviation, $\Delta B_s$		Outer Ring Width Deviation, $\Delta C_s$		Radial Runout of Assembled Inner Ring, $K_{ia}$	Radial Runout of Assembled Outer Ring, $K_{oa}$
over	incl	high	low	high	low	high	low	high	low	max	max
7.938 ( $\frac{5}{16}$ )	19.050 ( $\frac{3}{4}$ )	0	-10	—	—	+250	+120	—	—	10	—
19.050 ( $\frac{3}{4}$ )	30.162 (1 $\frac{3}{16}$ )	0	-13	0	-13	+250	+120	0	-130	13	15
30.162 (1 $\frac{3}{16}$ )	50.800 (2)	0	-13	0	-13	+250	+120	0	-130	15	20
50.800 (2)	82.550 (3 $\frac{1}{4}$ )	0	-15	0	-15	+250	+120	0	-130	20	25
82.550 (3 $\frac{1}{4}$ )	107.950 (4 $\frac{1}{4}$ )	0	-20	0	-20	+250	+120	0	-130	25	35
107.950 (4 $\frac{1}{4}$ )	120.650 (4 $\frac{3}{4}$ )	0	-20	0	-20	+380	+250	0	-130	25	35
120.650 (4 $\frac{3}{4}$ )	177.800 (7)	0	-25	0	-25	+380	+250	0	-130	30	45
177.800 (7)	184.150 (7 $\frac{1}{4}$ )	0	-30	0	-25	+380	+250	0	-130	30	45
184.150 (7 $\frac{1}{4}$ )	203.200 (8)	0	-30	0	-30	+380	+250	0	-130	40	50
203.200 (8)	260.350 (10 $\frac{1}{4}$ )	—	—	0	-30	—	—	0	-130	—	50
260.350 (10 $\frac{1}{4}$ )	317.500 (12 $\frac{1}{2}$ )	—	—	0	-36	—	—	0	-130	—	60

**Note**  $\Delta d_{mp}$ ,  $\Delta B_s$  and  $K_{ia}$  are found from the dimension category of  $d$ , and  $\Delta D_{mp}$ ,  $\Delta C_s$  and  $K_{oa}$  are from the dimension category of  $D$ .

**Table 4 Inscribed Circle Diameter for Metric Solid Needle Roller Bearings**

Nominal Inscribed Circle Diameter, $F_w$ (mm)		Deviation (F6) of Minimum Diameter, $F_{w\ min}$ , of Roller Inscribed Circle Diameter <sup>(1)</sup> ( $\mu\text{m}$ )	
over	incl	high	low
6	10	+ 22	+13
10	18	+ 27	+16
18	30	+ 33	+20
30	50	+ 41	+25
50	80	+ 49	+30
80	120	+ 58	+36
120	180	+ 68	+43
180	250	+ 79	+50
250	315	+ 88	+56
315	400	+ 98	+62
400	500	+108	+68

**Note** <sup>(1)</sup> When using a cylinder instead of an inner ring,  $F_{w\ min}$  is the diameter of the cylinder at which the internal clearance is zero in at least one radial direction. ( $F_{w\ min}$  is the minimum diameter of each inscribed circle diameter where deviation is suspected.)

**Table 5 Tolerance of Inscribed Circle Diameter for Inch Solid Needle Roller Bearings**

Nominal Inscribed Circle Diameter, $F_w$ (mm)		Deviation (F6) of Minimum Diameter, $F_{w\ min}$ , of Roller Inscribed Circle Diameter <sup>(1)</sup> ( $\mu\text{m}$ )	
over	incl	high	low
—	15.875 ( $\frac{5}{8}$ )	+43	+20
15.875 ( $\frac{5}{8}$ )	28.575 (1 $\frac{1}{8}$ )	+46	+23
28.575 (1 $\frac{1}{8}$ )	41.275 (1 $\frac{5}{8}$ )	+48	+25
41.275 (1 $\frac{5}{8}$ )	47.625 (1 $\frac{7}{8}$ )	+51	+25
47.625 (1 $\frac{7}{8}$ )	69.850 (2 $\frac{3}{4}$ )	+53	+28
69.850 (2 $\frac{3}{4}$ )	76.200 (3)	+58	+28
76.200 (3)	101.600 (4)	+61	+30
101.600 (4)	114.300 (4 $\frac{1}{2}$ )	+66	+30
114.300 (4 $\frac{1}{2}$ )	152.400 (6)	+69	+33
152.400 (6)	165.100 (6 $\frac{1}{2}$ )	+74	+33
165.100 (6 $\frac{1}{2}$ )	196.850 (7 $\frac{3}{4}$ )	+76	+36
196.850 (7 $\frac{3}{4}$ )	234.950 (9 $\frac{1}{4}$ )	+81	+36

**Note** <sup>(1)</sup> When using a cylinder instead of an inner ring,  $F_{w\ min}$  is the diameter of the cylinder at which the internal clearance is zero in at least one radial direction. ( $F_{w\ min}$  is the minimum diameter of each inscribed circle diameter where deviation is suspected.)

**APPLICATION**

**Specifications of Shaft and Housing**

The shaft and housing bore should be finished with recommended dimensional tolerance. Accuracy, surface roughness, and hardness should satisfy the conditions shown in **Table 6**.

**Shaft Inclination**

Shaft inclination due to deflection by external force and mounting error of the bearing should be the same as or less than the values found in **Table 7**.

**Table 6 Accuracy and Hardness of Shaft and Housing**

Category	Shaft		Housing Bore
	Raceway Surface	Fitting Surface	
Out-of-Roundness Tolerance	$\frac{IT3}{2}$	$\frac{IT3}{2}$ to $\frac{IT4}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Cylindrical Tolerance	$\frac{IT3}{2}$	$\frac{IT3}{2}$ to $\frac{IT4}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Roughness, Ra	0.4	0.8	1.6
Hardness	HRC58 to 64 Appropriate depth of hardening layer required	—	—

**Note** <sup>(1)</sup> Please refer to Section 5.2 on page A34 and Section 5.3 on page A35 for further details.

**Table 7 Shaft Inclination**

Bearing Width (mm)		Permissible Inclination (mm/mm)
over	incl	With cage
—	25	0.0015
25	50	0.0010
50	—	0.0005

**Fitting**

Depending on the application, the outer ring of NSK solid needle roller bearings is used with either a transitional fit or a tight fit.

Recommended fittings for solid needle roller bearings are shown in

**Table 8.**

Please refer to **Tables 5.2** and **5.3** on page A33 to fully consider operating conditions and choose the appropriate fittings.

For needle bearings without an inner ring, various radial inner clearances are achieved by selecting the proper shaft tolerance from **Table 4.6** on page A25.

**Table 8 Recommended Fittings for Solid Needle Roller Bearings**

Units: mm

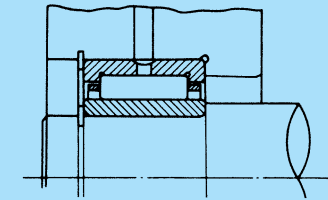
Code		Fitting Tolerance			
		Shaft or Inner Ring Rotation		Outer Ring Rotation	
		Shaft	Housing Bore	Shaft	Housing Bore
RLM, RNA RNAF HJ	Without Inner Ring	h5 ( $F_w \leq 80$ ) g6 ( $180 \geq F_w > 80$ ) f6 ( $F_w > 180$ )	H7	g5 ( $F_w \leq 80$ ) f6 ( $180 \geq F_w > 80$ ) e6 ( $F_w > 180$ )	N7
LM, NA NAF HJ+IR	With Inner Ring	k5 ( $d \leq 50$ ) m5 ( $d > 50$ )	H7	g6	N7

**Remarks** For metric needle bearings with an inner ring, if the inner and outer rings are fitted tighter than class k and K, respectively, a bearing with an internal clearance greater than CN clearance should be selected.

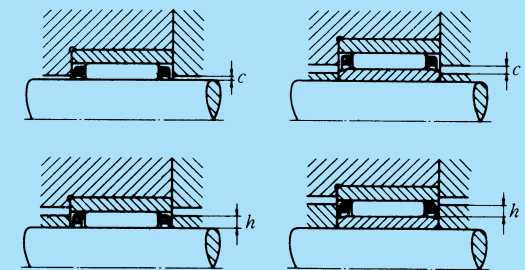
**Mounting**

Solid needle roller bearings generally require the shaft and housing shoulder to fix the inner and outer rings and prevent them from moving in the axial direction during operation (**Fig. 2**).

The unmarked surface of both the inner and outer rings should be placed onto the shaft or housing shoulder when mounting. The diameter of the shaft shoulder should be smaller than the outside diameter of the inner ring. Because the RNAF and NAF types do not have ribs, abutment and fillet dimensions should be carefully observed when designing the bearing surroundings. Examples of mounting, abutment and fillet dimensions are shown in **Fig. 3** and **Table 9**.



**Fig. 2 Example of Mounting**



**Fig. 3 Example of Mounting for RNAF and NAF**

**Table 9 Abutment and Fillet Dimensions for RNAF and NAF**

Units: mm

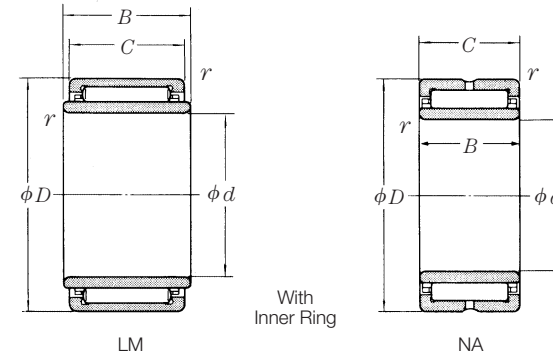
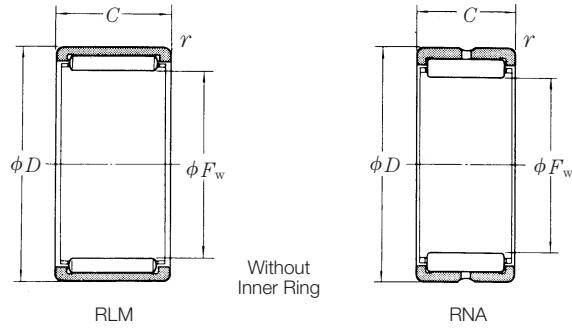
Nominal Inscribed Circle Diameter, $F_w$		Category of $D/F_w$	$c$	$h$
over	incl			
8	12	$D/F_w < 2.0$	0.15	1.35
		$D/F_w \geq 2.0$	0.3	2.8
12	22	$D/F_w < 1.59$	0.2	1.8
		$D/F_w \geq 1.59$	0.3	2.8
22	30	$D/F_w < 1.48$	0.3	2.2
		$D/F_w \geq 1.48$	0.4	3.2
30	55	$D/F_w < 1.34$	0.3	2.2
		$D/F_w \geq 1.34$	0.5	3.6
55	100	—	0.5	3.6

RLM • LM

RNA • NA

Inscribed Circle

Diameter 8 — 15 mm



$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
	$D$	$C$	$r_{min}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
<b>8</b>	15	10	0.15	4 300	3 800	440	390	60 000
	15	12	0.15	5 500	4 600	560	470	
	15	15	0.3	6 550	5 800	670	590	
	15	16	0.15	7 100	6 350	720	650	
<b>9</b>	16	12	0.3	6 150	5 400	625	550	40 000
	16	16	0.3	7 900	7 450	805	760	
	17	10	0.15	4 700	4 350	470	445	
<b>10</b>	15	10	0.3	4 500	4 900	460	500	36 000
	17	10	0.3	5 350	4 650	545	470	
	17	12	0.15	6 750	6 200	685	635	
	17	15	0.3	8 050	7 800	820	795	
	17	16	0.15	8 650	8 600	885	875	
	19	11	0.2	6 550	6 000	670	615	
<b>12</b>	17	12	0.3	6 150	7 650	625	780	30 000
	19	12	0.3	7 300	7 150	745	730	
	19	15	0.3	8 700	8 950	885	915	
	19	16	0.3	9 400	9 850	955	1 010	
	19	20	0.3	12 000	13 500	1 220	1 380	
	20	11	0.3	7 050	6 850	720	700	
<b>14</b>	22	12	0.3	9 350	9 150	955	935	24 000
	22	13	0.3	9 150	9 950	930	1 010	
	22	16	0.3	12 100	12 700	1 230	1 300	
	22	16	0.3	11 600	13 600	1 190	1 390	
	22	20	0.3	15 500	17 500	1 580	1 790	
	22	22	0.3	16 300	20 900	1 660	2 130	
<b>15</b>	20	8	0.3	4 050	4 800	415	490	24 000
	20	15	0.3	8 100	11 700	825	1 190	
	20	20	0.3	11 100	17 400	1 130	1 770	
	22	12	0.3	8 300	8 900	845	905	
	22	15	0.3	9 900	11 100	1 010	1 140	
	22	20	0.3	13 600	16 800	1 390	1 710	
23	16	0.3	12 300	14 800	1 250	1 510	24 000	
23	20	0.3	15 500	20 100	1 590	2 050		

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

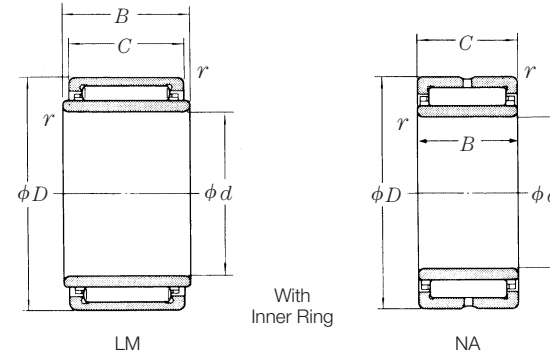
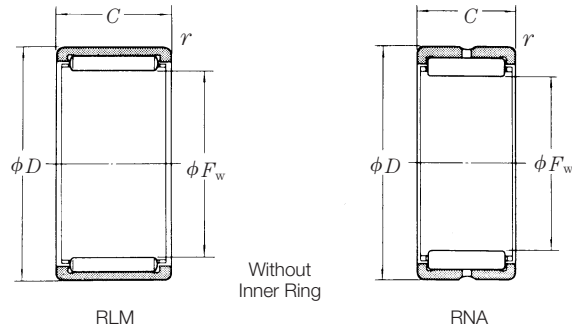
RLM	Without Inner Ring			With Inner Ring LM • NA	Boundary Dimensions (mm)		Mass (kg)	
	RNA49	RNA59	RNA69		$d$	$B$	Without Inner Ring	approx With Inner Ring
<b>RLM81512-1</b>	<b>RNA496</b>			—	—	—	0.0070	—
<b>RLM815</b>				<b>LM81512-1</b>	5	12	0.0083	0.011
<b>RLM81516-1</b>				<b>LM81516-1</b>	5	16	0.010	—
<b>RLM912</b>				<b>LM91212-1</b>	6	12	0.0092	0.013
<b>RLM916</b>				—	—	—	0.011	—
	<b>RNA497</b>			—	—	—	0.0091	—
<b>RLM1010</b>				—	—	—	0.0055	—
<b>RLM101710</b>				—	—	—	0.0082	—
<b>RLM101712-1</b>				<b>LM101712-1</b>	7	12	0.0097	0.014
<b>RLM101715</b>				—	—	—	0.012	—
<b>RLM101716-1</b>				<b>LM101716-1</b>	7	16	0.013	0.018
	<b>RNA498</b>			<b>NA498</b>	8	11	0.012	0.015
<b>RLM1212</b>				<b>LM1212</b>	8	12.2	0.0076	0.013
<b>RLM121912</b>				<b>LM121912</b>	8	12.2	0.011	0.017
<b>RLM121915</b>				<b>LM121915</b>	8	15.2	0.014	0.021
<b>RLM121916-1</b>				<b>LM121916-1</b>	9	16	0.014	0.022
<b>RLM121920-1</b>				—	—	—	0.018	—
	<b>RNA499</b>			<b>NA499</b>	9	11	0.013	0.017
<b>RLM1412</b>				—	—	—	0.014	—
<b>RLM1416</b>	<b>RNA4900</b>			<b>NA4900</b>	10	13	0.016	0.024
				<b>LM1416</b>	10	16.2	0.019	0.028
<b>RLM1420</b>		<b>RNA5900</b>		<b>NA5900</b>	10	16	0.022	0.031
				<b>LM1420</b>	10	20.2	0.024	0.036
			<b>RNA6900</b>	<b>NA6900</b>	10	22	0.027	0.040
<b>RLM158</b>				<b>LM158</b>	10	8.2	0.0061	0.012
<b>RLM1515</b>				<b>LM1515</b>	10	15.2	0.011	0.022
<b>RLM1520</b>				<b>LM1520</b>	10	20.2	0.015	0.030
<b>RLM152212</b>				<b>LM152212</b>	10	12.2	0.013	0.022
<b>RLM152215</b>				<b>LM152215</b>	10	15.2	0.016	0.027
<b>RLM152220</b>				<b>LM152220</b>	10	20.2	0.021	0.036
<b>RLM152316-1</b>				—	—	—	0.021	—
<b>RLM152320-1</b>				—	—	—	0.026	—

RLM • LM

RNA • NA

Inscribed Circle

Diameter 16 — 21 mm



F <sub>w</sub>	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )	
	D	C	r min	C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>		
16	24	13	0.3	10 100	11 700	1 030	1 190	28 000	
	24	16	0.3	12 900	14 200	1 310	1 450	22 000	
	24	16	0.3	12 800	16 000	1 310	1 630	28 000	
	24	20	0.3	16 500	19 500	1 680	1 990	22 000	
	24	22	0.3	17 900	24 500	1 830	2 500	28 000	
	17	22	10	0.3	5 850	7 950	595	810	20 000
22		20	0.3	11 800	19 500	1 200	1 990	20 000	
24		15	0.5	11 000	13 200	1 120	1 350	20 000	
24		25	0.5	18 200	25 300	1 850	2 580	20 000	
25		16	0.3	13 600	15 500	1 390	1 580	20 000	
25		20	0.3	16 200	21 900	1 650	2 230	20 000	
18	25	15	0.5	11 500	14 300	1 170	1 450	20 000	
	25	17	0.5	13 300	17 200	1 350	1 750	20 000	
	25	20	0.5	15 800	21 500	1 610	2 190	20 000	
	25	25	0.5	19 000	27 300	1 940	2 780	20 000	
	26	13	0.3	10 500	12 700	1 070	1 290	24 000	
	26	16	0.3	12 700	16 200	1 300	1 650	20 000	
19	27	16	0.5	14 300	17 000	1 460	1 730	18 000	
	27	20	0.5	18 300	23 400	1 870	2 380	18 000	
	20	27	10	0.5	7 950	9 150	810	930	18 000
		27	15	0.5	11 900	15 400	1 220	1 570	18 000
27		20	0.5	16 400	23 200	1 670	2 370	18 000	
27		20	0.5	16 400	23 200	1 670	2 370	18 000	
21	27	25	0.5	19 800	29 500	2 010	3 000	18 000	
	28	13	0.3	10 800	13 600	1 100	1 390	22 000	
	28	16	0.3	14 400	19 700	1 470	2 010	18 000	
	28	18	0.3	15 700	21 900	1 600	2 240	22 000	
	28	20	0.5	18 200	23 500	1 860	2 400	18 000	
	28	23	0.3	19 300	28 600	1 960	2 920	22 000	

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

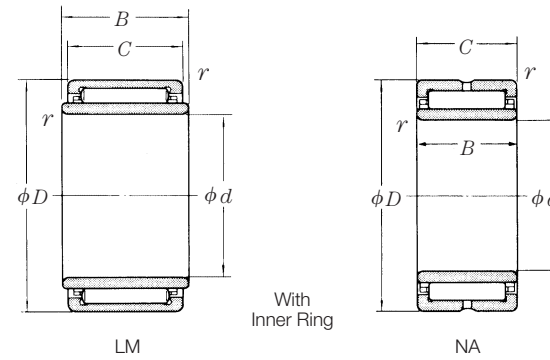
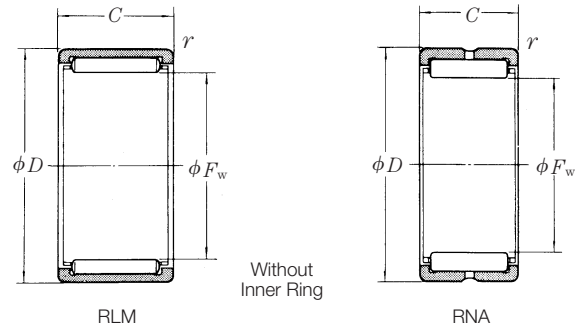
RLM	Without Inner Ring			With Inner Ring	Boundary Dimensions (mm)		Mass (kg)	
	RNA49	RNA59	RNA69		d	B	Without Inner Ring	With Inner Ring
RLM1616	RNA4901			NA4901	12	13	0.018	0.027
	RNA5901			LM1616	12	16.2	0.021	0.032
				NA5901	12	16	0.024	0.035
RLM1620	RNA6901			LM1620	12	20.2	0.027	0.041
				NA6901	12	22	0.030	0.045
RLM1710 RLM1720 RLM172415				LM1710	12	10.2	0.0080	0.017
				LM1720	12	20.2	0.016	0.034
				LM172415	12	15.2	0.018	0.032
				LM172425	12	25.2	0.030	0.052
				—	—	—	0.023	—
RLM172516-1 RLM172520-1				—	—	—	0.029	—
				LM1815	15	15.2	0.019	0.028
				LM1817	15	17.2	0.021	0.031
RLM1820				LM1820	15	20.2	0.025	0.037
				LM1825	15	25.2	0.032	0.047
				—	—	—	0.020	—
RLM182616-1 RLM182620-1	RNA49/14			—	—	—	0.024	—
				—	—	—	0.030	—
				—	—	—	0.030	—
RLM1916 RLM1920				LM1916	15	16.2	0.025	0.039
				LM1920	15	20.2	0.031	0.048
RLM2010 RLM2015 RLM2020 RLM2020				LM2010	15	10.2	0.014	0.025
				LM2015	15	15.2	0.021	0.037
				LM2020	15	20.2	0.028	0.049
				LM2020-1	15	20	0.028	0.048
RLM2025 RLM202816-1	RNA4902			LM2025	15	25.2	0.035	0.061
				NA4902	15	13	0.021	0.035
RLM202820	RNA5902			—	—	—	0.026	—
				NA5902	15	18	0.032	0.051
				LM202820	15	20.2	0.033	0.055
RLM2116 RLM2120	RNA6902			NA6902	15	23	0.039	0.064
				LM2116	17	16.2	0.027	0.042
				LM2120	17	20.2	0.034	0.053

RLM • LM

RNA • NA

Inscribed Circle

Diameter 22 — 29 mm



$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )	
	$D$	$C$	$r_{min}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$		
<b>22</b>	29	15	0.5	12 900	17 500	1 310	1 780	16 000	
	29	20	0.5	17 700	26 400	1 810	2 690	16 000	
	29	25	0.5	21 300	33 500	2 170	3 400	16 000	
	30	13	0.3	11 600	15 400	1 190	1 570	20 000	
	30	16	0.5	15 600	19 800	1 590	2 020	16 000	
	30	18	0.3	16 800	24 800	1 720	2 530	20 000	
	30	20	0.5	20 000	27 200	2 030	2 780	16 000	
	30	23	0.3	20 700	32 500	2 110	3 300	20 000	
	<b>24</b>	31	20	0.5	18 200	28 100	1 860	2 870	15 000
		31	28	0.5	23 700	39 500	2 420	4 000	15 000
		32	16	0.5	16 100	21 300	1 650	2 170	15 000
		32	20	0.5	20 700	29 200	2 110	2 980	15 000
<b>25</b>	32	12	0.5	10 300	13 700	1 050	1 400	14 000	
	32	20	0.5	18 800	29 700	1 920	3 050	14 000	
	32	25	0.5	22 700	37 500	2 310	3 850	14 000	
	33	16	0.5	16 800	22 600	1 710	2 300	14 000	
	33	20	0.5	21 500	31 000	2 190	3 150	14 000	
	33	25	0.5	25 900	39 500	2 640	4 050	14 000	
<b>26</b>	37	17	0.3	19 700	22 900	2 010	2 340	18 000	
	37	23	0.3	27 800	35 500	2 830	3 650	18 000	
	37	30	0.3	36 500	50 500	3 700	5 150	18 000	
<b>28</b>	35	20	0.5	19 900	33 000	2 030	3 350	12 000	
	35	25	0.3	23 900	42 000	2 440	4 250	12 000	
	37	20	0.5	24 200	33 500	2 460	3 450	12 000	
<b>29</b>	37	30	0.5	34 000	52 500	3 450	5 350	12 000	
	39	17	0.3	22 400	30 500	2 290	3 150	15 000	
	39	23	0.3	28 300	41 500	2 890	4 200	15 000	
	39	30	0.3	37 000	58 500	3 800	6 000	15 000	
	38	20	0.5	25 100	36 000	2 560	3 650	12 000	
38	20	0.5	23 400	36 500	2 390	3 700	12 000		
38	30	0.5	35 500	55 500	3 600	5 650	12 000		
38	30	0.3	32 000	54 000	3 250	5 550	12 000		

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

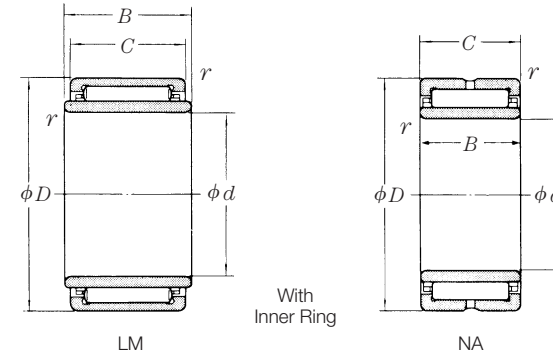
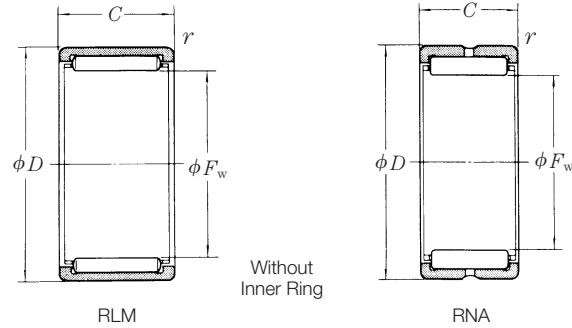
Bearing Numbers	Boundary Dimensions (mm)		Mass (kg)	
	$d$	$B$	Without Inner Ring	With Inner Ring
Without Inner Ring				
RLM				
RNA49				
RNA59				
RNA69				
With Inner Ring				
LM • NA				
<b>RLM2215</b>	17	15.2	0.023	0.041
<b>RLM2220</b>	17	20.2	0.030	0.054
<b>RLM2225</b>	17	25.2	0.038	0.068
<b>RLM223016</b>	17	13	0.023	0.038
		16.2	0.028	0.045
		18	0.034	0.055
<b>RLM223020</b>	17	20.2	0.035	0.060
		23	0.041	0.068
<b>RLM2420</b>	20	20.2	0.033	0.054
		28.2	0.046	0.076
		16.2	0.030	0.048
		20.2	0.038	0.060
<b>RLM2512</b>	20	12.2	0.020	0.036
		20.2	0.034	0.061
		25.2	0.042	0.076
<b>RLM253316-1</b>	20	—	0.032	—
		20.2	0.040	0.068
		25.2	0.050	0.085
<b>RLM2620</b>	22	17	0.055	0.077
		23	0.089	0.12
		30	0.098	0.14
<b>RLM2820</b>	22	20.2	0.038	0.062
		25.2	0.047	0.092
		20.2	0.050	0.087
<b>RLM283730</b>	22	30.2	0.075	0.13
		17	0.056	0.086
		23	0.091	0.135
		30	0.096	0.15
<b>RLM2920</b>	25	20.2	0.052	0.079
		20	0.052	0.078
		30.2	0.078	0.118
		30.2	0.078	0.117

RLM • LM

RNA • NA

Inscribed Circle

Diameter 30 — 38 mm



$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
	$D$	$C$	$r$ min	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
<b>30</b>	37	15	0.5	14 800	23 000	1 500	2 340	12 000
	37	20	0.5	20 300	34 500	2 070	3 550	12 000
	37	25	0.5	24 500	44 000	2 490	4 500	12 000
	40	20	0.5	25 000	36 000	2 550	3 650	12 000
	40	25	0.5	30 000	46 000	3 100	4 650	12 000
	40	30	0.5	35 000	56 000	3 600	5 700	12 000
	42	17	0.3	21 400	26 800	2 180	2 740	14 000
	42	23	0.3	30 000	41 500	3 100	4 250	14 000
	42	30	0.3	39 500	59 000	4 050	6 050	14 000
<b>32</b>	42	20	0.5	25 800	38 000	2 630	3 900	11 000
	42	30	0.5	36 500	59 000	3 700	6 050	11 000
	45	17	0.3	22 200	28 700	2 270	2 930	13 000
<b>35</b>	45	23	0.3	31 500	44 500	3 200	4 550	13 000
	45	30	0.3	41 000	63 500	4 200	6 450	13 000
	42	20	0.5	22 300	41 000	2 270	4 200	10 000
<b>37</b>	42	30	0.5	31 000	63 500	3 200	6 450	10 000
	45	20	0.5	27 500	42 500	2 800	4 350	10 000
	45	25	0.5	33 000	54 500	3 400	5 550	10 000
	45	30	0.5	38 500	66 000	3 950	6 750	10 000
	47	17	0.3	23 900	32 500	2 430	3 300	12 000
	47	23	0.3	33 500	50 500	3 450	5 150	12 000
	47	30	0.3	44 000	71 500	4 500	7 300	12 000
	47	20	0.6	28 200	45 000	2 880	4 550	9 500
	47	30	0.6	39 500	69 500	4 050	7 100	9 500
<b>38</b>	47	30	0.6	39 500	69 500	4 050	7 100	9 500
	48	15	0.6	20 900	30 500	2 130	3 150	9 000
	48	20	0.6	29 000	47 000	2 960	4 800	9 000
	48	25	0.6	35 000	60 000	3 600	6 100	9 000
	48	30	0.6	41 000	73 000	4 150	7 450	9 000

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

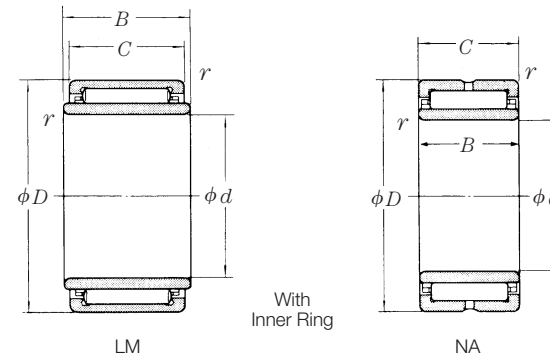
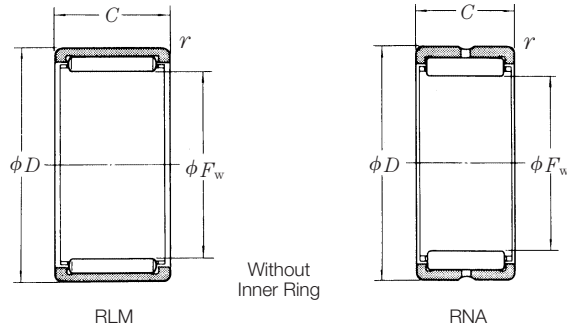
Bearing Numbers				Boundary Dimensions (mm)	Mass (kg)		
Without Inner Ring		With Inner Ring			Without Inner Ring	With Inner Ring	
RLM	RNA49	RNA59	RNA69	$d$	$B$	approx	approx
<b>RLM3015</b>				25	15.2	0.030	0.055
<b>RLM3020</b>				25	20.2	0.040	0.073
<b>RLM3025</b>				25	25.2	0.050	0.092
<b>RLM304020</b>				25	20.2	0.060	0.093
<b>RLM304025</b>				25	25.2	0.075	0.12
<b>RLM304030</b>				25	30.2	0.090	0.14
	<b>RNA4905</b>			25	17	0.063	0.091
		<b>RNA5905</b>		25	23	0.10	0.14
			<b>RNA6905</b>	25	30	0.11	0.16
<b>RLM3220</b>				28	20.2	0.064	0.090
<b>RLM3230</b>				28	30.2	0.096	0.14
	<b>RNA49/28</b>			28	17	0.076	0.099
		<b>RNA59/28</b>		28	23	0.11	0.145
			<b>RNA69/28</b>	28	30	0.13	0.175
<b>RLM3520</b>				30	20.2	0.046	0.085
<b>RLM3530</b>				30	30.2	0.070	0.13
<b>RLM354520</b>				30	20.2	0.069	0.11
<b>RLM354525</b>				30	25.2	0.086	0.135
<b>RLM354530</b>				30	30.2	0.10	0.16
	<b>RNA4906</b>			30	17	0.072	0.105
		<b>RNA5906</b>		30	23	0.11	0.15
			<b>RNA6906</b>	30	30	0.13	0.19
<b>RLM3720</b>				32	20.3	0.072	0.115
<b>RLM3730</b>				32	30.3	0.11	0.175
<b>RLM374730-1</b>				32	30	0.11	0.17
<b>RLM3815</b>				32	15.3	0.056	0.094
<b>RLM3820</b>				32	20.3	0.074	0.125
<b>RLM3825</b>				32	25.3	0.093	0.16
<b>RLM3830</b>				32	30.3	0.11	0.195

RLM • LM

RNA • NA

Inscribed Circle

Diameter 40 — 50 mm



$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
	$D$	$C$	$r_{min}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
40	50	15	0.6	21 400	32 000	2 180	3 300	9 000
	50	20	0.6	29 700	49 000	3 050	5 000	9 000
	50	20	0.6	29 700	49 000	3 050	5 000	9 000
	50	25	0.6	36 000	62 500	3 650	6 400	9 000
	50	30	0.6	42 000	76 500	4 250	7 800	9 000
	52	20	0.6	29 900	45 000	3 050	4 600	10 000
	52	27	0.6	40 500	66 000	4 100	6 750	10 000
	52	36	0.6	56 000	101 000	5 700	10 300	10 000
42	52	20	0.3	32 000	54 500	3 250	5 600	8 500
	52	30	0.3	44 500	84 500	4 550	8 600	8 500
	55	20	0.6	30 500	47 500	3 100	4 800	10 000
	55	27	0.6	41 500	69 500	4 200	7 100	10 000
43	53	20	0.3	32 000	55 000	3 250	5 600	8 000
	53	30	0.3	44 500	84 500	4 550	8 600	8 000
45	55	20	0.6	31 000	53 500	3 150	5 500	8 000
	55	25	0.6	37 500	68 500	3 800	7 000	8 000
	55	30	0.6	43 500	83 500	4 450	8 500	8 000
	58	20	0.6	34 000	56 000	3 500	5 700	9 500
47	57	20	0.3	33 000	59 500	3 350	6 050	7 500
	57	30	0.3	46 500	91 500	4 700	9 350	7 500
48	62	22	0.6	39 000	61 500	3 950	6 300	9 000
	62	30	0.6	54 500	95 000	5 550	9 700	9 000
	62	40	0.6	72 000	137 000	7 350	13 900	9 000
50	60	20	0.6	33 000	60 500	3 350	6 150	7 100
	60	30	0.6	46 500	94 000	4 750	9 550	7 100
	62	20	0.6	35 500	60 500	3 600	6 150	7 100
	62	25	0.6	43 000	77 500	4 400	7 900	7 100
	62	25	0.6	43 000	77 500	4 400	7 900	7 100
	62	30	0.6	50 000	94 500	5 100	9 600	7 100
	62	35	0.6	66 500	136 000	6 800	13 900	7 100
	65	22	0.6	43 000	72 000	4 400	7 300	8 500

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

Bearing Numbers				Boundary Dimensions (mm)		Mass (kg)	
Without Inner Ring		With Inner Ring		$d$	$B$	approx	
RLM	RNA49 RNA59 RNA69	LM · NA				Without Inner Ring	With Inner Ring
RLM4015 RLM4020 RLM405020-1			LM4015 LM4020 LM405020-1	35	15.3	0.058	0.092
				35	20.3	0.078	0.125
				35	20	0.125	0.125
RLM4025 RLM4030			LM4025 LM4030	35	25.3	0.097	0.155
	RNA49/32		NA49/32	35	30.3	0.12	0.19
				32	20	0.092	0.16
		RNA59/32	NA59/32	32	27	0.15	0.24
		RNA69/32	NA69/32	32	36	0.17	0.29
RLM425220-1 RLM425230-1			—	—	—	0.081	—
	RNA4907		NA4907	—	—	0.12	—
				35	20	0.11	0.17
		RNA5907	NA5907	35	27	0.175	0.25
		RNA6907	NA6907	35	36	0.20	0.315
RLM435320-1 RLM435330-1			LM435320-1 LM435330-1	38	20	0.082	0.132
				38	30	0.125	0.199
RLM4520 RLM4525 RLM4530			LM4520 LM4525 LM4530	40	20.3	0.086	0.14
	RNA49/38		—	40	25.3	0.11	0.17
				40	30.3	0.13	0.21
				—	—	0.12	—
RLM475720-1 RLM475730-1			LM475720-1 LM475730-1	42	20	0.089	0.12
				42	30	0.14	0.22
	RNA4908		NA4908	40	22	0.15	0.24
		RNA5908	NA5908	40	30	0.23	0.355
		RNA6908	NA6908	40	40	0.265	0.435
RLM5020 RLM5030 RLM506220			LM5020 LM5030 LM506220	42	20.3	0.098	0.19
				42	30.3	0.15	0.28
				42	20.3	0.12	0.21
RLM506225 RLM506225-1 RLM506230			LM506225 LM506225-1 LM506230	42	25.3	0.155	0.265
				45	25	0.155	0.22
				42	30.3	0.18	0.315
RLM506235-1			LM506235-1	45	35	0.21	0.31
	RNA49/42		—	—	—	0.17	—

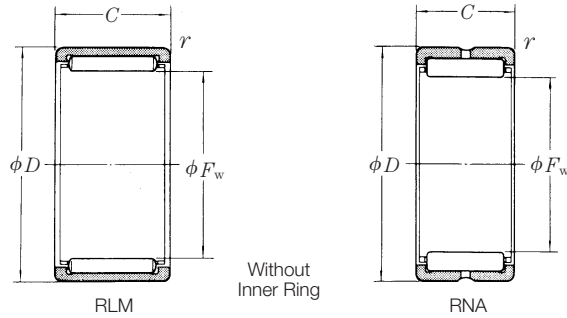


SOLID NEEDLE ROLLER BEARINGS

RLM • LM

RNA • NA

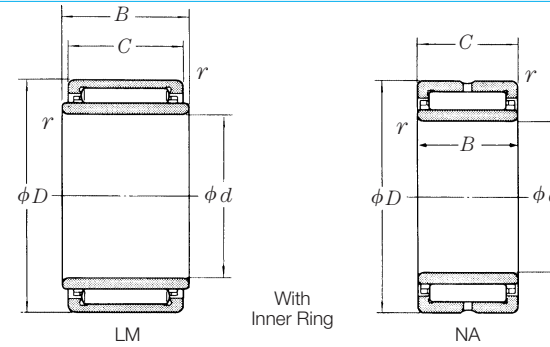
Inscribed Circle  
Diameter 52 — 73 mm



Boundary Dimensions (mm)				Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
<i>F<sub>w</sub></i>	<i>D</i>	<i>C</i>	<i>r</i> <sub>min</sub>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	
<b>52</b>	68	22	0.6	41 000	67 500	4 150	6 900	8 000
	68	30	0.6	57 000	104 000	5 800	10 600	8 000
	68	40	0.6	76 000	149 000	7 750	15 200	8 000
<b>55</b>	65	30	0.6	49 000	104 000	5 000	10 600	6 300
	65	40	0.6	64 000	146 000	6 550	14 900	6 300
	67	20	0.6	38 000	68 000	3 850	6 900	6 300
	67	25	0.6	46 000	87 000	4 700	8 850	6 300
	68	25	0.5	48 000	92 500	4 900	9 450	6 300
	68	35	0.3	63 500	132 000	6 500	13 500	6 300
<b>58</b>	70	22	0.6	45 000	78 000	4 600	7 950	7 500
	72	22	0.6	42 500	73 500	4 350	7 500	7 100
	72	30	0.6	59 500	113 000	6 050	11 500	7 100
	72	40	0.6	79 000	163 000	8 050	16 600	7 100
<b>60</b>	70	40	0.6	66 000	156 000	6 750	15 900	6 000
	72	25	0.3	50 000	99 500	5 100	10 100	6 000
	72	30	0.6	58 000	120 000	5 900	12 300	6 000
	72	35	0.3	65 500	142 000	6 700	14 400	6 000
	72	40	0.6	73 000	162 000	7 450	16 600	6 000
<b>63</b>	75	22	0.6	48 000	87 500	4 900	8 900	7 100
	80	25	1	53 500	87 500	5 450	8 950	6 700
	80	34	1	73 500	133 000	7 500	13 600	6 700
<b>65</b>	80	45	1	93 500	181 000	9 550	18 500	6 700
	78	35	0.6	67 500	151 000	6 900	15 400	5 300
	82	25	1	60 500	105 000	6 200	10 700	6 300
<b>68</b>	82	25	0.6	56 500	112 000	5 750	11 500	5 000
	82	35	0.6	78 000	169 000	7 950	17 300	5 000
	85	25	1	56 000	95 500	5 700	9 750	6 300
	85	34	1	77 500	145 000	7 900	14 800	6 300
	85	45	1	98 000	197 000	10 000	20 100	6 300
<b>70</b>	88	25	1	63 000	113 000	6 450	11 500	6 000
	90	25	1	58 500	103 000	5 950	10 500	5 600
<b>72</b>	90	34	1	81 000	157 000	8 250	16 000	5 600
	90	45	1	103 000	213 000	10 500	21 800	5 600
	90	25	1	64 500	117 000	6 550	12 000	4 800
<b>73</b>	90	35	1	88 500	177 000	9 000	18 000	4 800

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

NSK NEEDLE BEARING



Bearing Numbers				Boundary Dimensions (mm)		Mass (kg)	
RLM	Without Inner Ring			With Inner Ring		approx	
	RNA49	RNA59	RNA69	LM · NA	<i>d</i>	<i>B</i>	Without Inner Ring
<b>RNA4909</b>	<b>RNA5909</b>	<b>RNA6909</b>	<b>NA4909</b>	45	22	0.19	0.28
			<b>NA5909</b>	45	30	0.27	0.39
			<b>NA6909</b>	45	40	0.335	0.495
<b>RLM5530</b> <b>LM5540</b> <b>RLM556720</b>	<b>LM5530</b> <b>LM5540</b> <b>LM556720</b>	<b>LM5530</b> <b>LM5540</b> <b>LM556720</b>	45	30.3	0.16	0.34	
			45	40.3	0.215	0.46	
			45	20.3	0.13	0.25	
			45	25.3	0.165	0.32	
			50	25	0.18	0.27	
			50	35	0.25	0.37	
<b>RLM556725</b> <b>RLM556825-1</b> <b>RLM556835-1</b>	<b>LM556725</b> <b>LM556825-1</b> <b>LM556835-1</b>	<b>LM556725</b> <b>LM556825-1</b> <b>LM556835-1</b>	—	—	0.18	—	
			<b>NA4910</b>	50	22	0.18	0.295
			<b>NA5910</b>	50	30	0.25	0.405
			<b>NA6910</b>	50	40	0.32	0.53
<b>RLM6040</b> <b>RLM607225</b> <b>RLM607230</b>	<b>LM6040</b> <b>LM607225-1</b> <b>LM607230</b>	<b>LM6040</b> <b>LM607225-1</b> <b>LM607230</b>	50	40.3	0.235	0.505	
			55	25	0.175	0.26	
			50	30.3	0.21	0.41	
			<b>LM607235-1</b>	55	35	0.245	0.37
			<b>LM607240</b>	50	40.3	0.28	0.545
<b>RLM607235-1</b> <b>RLM607240</b>	<b>LM607235-1</b> <b>LM607240</b>	<b>LM607235-1</b> <b>LM607240</b>	—	—	0.20	—	
			<b>NA4911</b>	55	25	0.26	0.40
			<b>NA5911</b>	55	34	0.37	0.56
<b>RLM657835-1</b>	<b>NA6911</b>	<b>NA6911</b>	55	45	0.475	0.73	
			—	—	0.29	—	
			—	—	0.27	—	
<b>RLM688225-1</b> <b>RLM688235-1</b>	<b>LM688225-1</b> <b>LM688235-1</b> <b>NA4912</b>	<b>LM688225-1</b> <b>LM688235-1</b> <b>NA4912</b>	60	25	0.23	0.39	
			60	35	0.325	0.54	
			60	25	0.28	0.435	
<b>RLM657835-1</b>	<b>RNA5912</b>	<b>RNA6912</b>	<b>NA5912</b>	60	34	0.415	0.625
			<b>NA6912</b>	60	45	0.485	0.76
			—	—	0.31	—	
			—	—	0.31	—	
<b>RLM688225-1</b> <b>RLM688235-1</b>	<b>RNA4912</b>	<b>RNA5912</b>	<b>NA4913</b>	65	25	0.32	0.465
			<b>NA5913</b>	65	34	0.48	0.675
			<b>NA6913</b>	65	45	0.53	0.79
<b>RLM739025-1</b> <b>RLM739035-1</b>	<b>LM739025-1</b> <b>LM739035-1</b>	<b>LM739025-1</b> <b>LM739035-1</b>	—	—	0.305	—	
			65	35	0.43	0.67	

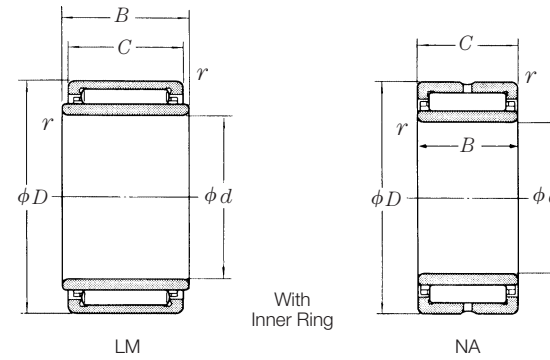
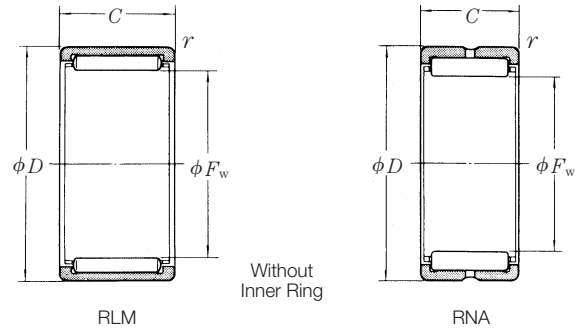
SOLID NEEDLE ROLLER BEARINGS

RLM • LM

RNA • NA

Inscribed Circle

Diameter 75 — 115 mm

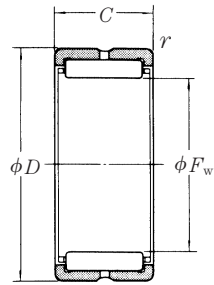


NSK NEEDLE BEARING

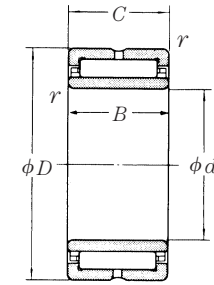
$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
	$D$	$C$	$r_{min}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
75	92	25	1	64 000	118 000	6 550	12 000	4 800
	92	35	1	88 000	177 000	8 950	18 100	4 800
	95	30	1	83 500	148 000	8 550	15 100	5 600
80	95	25	1	62 500	125 000	6 400	12 800	4 500
	95	35	1	86 000	189 000	8 800	19 200	4 500
	100	30	1	80 500	143 000	8 200	14 600	5 300
	100	40	1	107 000	206 000	10 900	21 000	5 300
85	100	54	1	143 000	298 000	14 500	30 500	5 300
	105	25	1	79 000	143 000	8 100	14 600	4 000
	105	30	1	84 000	155 000	8 600	15 800	5 000
	105	35	1	109 000	215 000	11 100	21 900	4 000
90	105	40	1	112 000	222 000	11 400	22 700	5 000
	105	54	1	149 000	325 000	15 200	33 000	5 000
	110	25	1	82 500	154 000	8 400	15 700	4 000
	110	30	1	87 500	166 000	8 950	17 000	4 500
95	110	40	1	116 000	239 000	11 900	24 400	4 500
	110	54	1	155 000	345 000	15 900	35 500	4 500
	115	26	1	85 500	164 000	8 700	16 700	3 600
	115	30	1	95 500	189 000	9 750	19 300	4 300
100	120	26	1	86 000	168 000	8 750	17 100	3 600
	120	35	1.1	104 000	214 000	10 600	21 800	4 000
	120	46	1.1	138 000	310 000	14 100	31 500	4 000
	120	63	1.1	174 000	415 000	17 800	42 500	4 000
105	125	35	1.1	108 000	228 000	11 000	23 300	4 000
	125	46	1.1	143 000	330 000	14 600	33 500	4 000
	125	63	1.1	181 000	445 000	18 400	45 000	4 000
110	130	30	1	101 000	213 000	10 300	21 800	3 200
	130	35	1.1	111 000	242 000	11 400	24 700	3 800
	130	40	1	134 000	305 000	13 700	31 500	3 200
	130	46	1.1	148 000	350 000	15 100	35 500	3 800
115	130	63	1.1	187 000	470 000	19 100	48 000	3 800
	140	40	1.1	144 000	295 000	14 700	30 000	3 600
	140	54	1.1	193 000	430 000	19 700	43 500	3 600

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

Bearing Numbers	Boundary Dimensions (mm)		Mass (kg)	
	$d$	$B$	Without Inner Ring	With Inner Ring
RLM759225-1 RLM759235-1 RNA49/68	—	—	0.315 0.44 0.46	— — —
RLM809525-1 RLM809535-1 RNA4914 RNA5914 RNA6914	70 70 70	25 35 30 40 54	0.29 0.405 0.47 0.69 0.89	0.52 0.73 0.74 1.05 1.4
RLM8510525-1 RLM8510535-1 RNA4915 RNA5915 RNA6915	75 75 75	25 30 35 40 54	0.42 0.50 0.59 0.735 0.96	0.67 0.79 0.93 1.1 1.5
RLM9011025-1 RNA4916 RNA5916 RNA6916	80 80 80	25 30 40 54	0.44 0.53 0.75 0.99	0.70 0.835 1.15 1.55
RLM9511526-1 RNA49/82	85	26	0.48 0.57	0.75 —
RLM10012026-1 RNA4917 RNA5917 RNA6917	90 85 85	26 35 46 63	0.505 0.68 0.99 1.2	0.81 1.25 1.75 2.25
RLM11013030-1 RNA4918 RNA5918 RNA6918	90 90 90	35 46 63	0.72 1.05 1.35	1.35 1.85 2.45
RLM11013040-1 RNA4919 RNA5919 RNA6919	95 95	35 46 63	0.635 0.74 0.85 1.15 1.5	— 1.4 — 2.0 2.65
RNA4920 RNA5920	100 100	40 54	1.15 1.8	1.95 2.85



RNA



NA

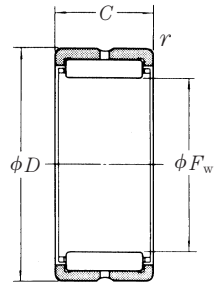
Boundary Dimensions (mm)				Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )
<i>F<sub>w</sub></i>	<i>D</i>	<i>B, C</i>	<i>r</i> <sub>min</sub>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	
<b>120</b>	140	30	1	99 500	214 000	10 100	21 900	3 400
<b>125</b>	150	40	1.1	149 000	315 000	15 200	32 500	3 200
	150	54	1.1	200 000	460 000	20 300	47 000	3 200
<b>130</b>	150	30	1	105 000	238 000	10 700	24 300	3 200
<b>135</b>	165	45	1.1	192 000	395 000	19 600	40 500	3 000
	165	60	1.1	253 000	565 000	25 800	58 000	3 000
<b>145</b>	165	35	1.1	127 000	315 000	12 900	32 000	2 800
<b>150</b>	180	50	1.5	228 000	515 000	23 200	52 500	2 800
	180	67	1.5	299 000	725 000	30 500	74 000	2 800
<b>155</b>	175	35	1.1	133 000	340 000	13 600	35 000	2 600
<b>160</b>	190	50	1.5	235 000	545 000	24 000	55 500	2 600
	190	67	1.5	310 000	775 000	31 500	79 000	2 600
<b>165</b>	190	40	1.1	180 000	440 000	18 300	45 000	2 400
<b>170</b>	210	60	2	315 000	645 000	32 000	66 000	2 400
<b>175</b>	200	40	1.1	184 000	465 000	18 700	47 000	2 200
<b>180</b>	220	60	2	325 000	695 000	33 500	71 000	2 200
<b>185</b>	215	45	1.1	224 000	540 000	22 900	55 000	2 200
<b>190</b>	230	60	2	340 000	745 000	34 500	76 000	2 200
<b>195</b>	225	45	1.1	230 000	565 000	23 500	58 000	2 000
<b>205</b>	250	69	2	400 000	940 000	41 000	96 000	2 000
<b>210</b>	240	50	1.5	268 000	705 000	27 300	72 000	1 900
<b>215</b>	260	69	2	415 000	1 000 000	42 000	102 000	1 900
	250	50	1.5	274 000	740 000	27 900	75 500	1 800
<b>225</b>	280	80	2.1	525 000	1 140 000	53 500	116 000	1 900
<b>240</b>	270	50	1.5	286 000	805 000	29 100	82 000	1 700
<b>245</b>	300	80	2.1	545 000	1 230 000	55 500	125 000	1 700
<b>265</b>	300	60	2	375 000	1 070 000	38 500	109 000	1 500
	320	80	2.1	590 000	1 400 000	60 500	142 000	1 600

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

Bearing Numbers				Boundary Dimensions (mm)	Mass (kg)	
Without Inner Ring			With Inner Ring		approx	
RNA48	RNA49	RNA59	NA	<i>d</i>	Without Inner Ring	With Inner Ring
<b>RNA4822</b>			<b>NA4822</b>	110	0.67	1.1
	<b>RNA4922</b>		<b>NA4922</b>	110	1.25	2.1
		<b>RNA5922</b>	<b>NA5922</b>	110	1.95	3.05
<b>RNA4824</b>			<b>NA4824</b>	120	0.71	1.15
	<b>RNA4924</b>		<b>NA4924</b>	120	1.9	2.9
		<b>RNA5924</b>	<b>NA5924</b>	120	2.7	4.05
<b>RNA4826</b>			<b>NA4826</b>	130	0.92	1.8
	<b>RNA4926</b>		<b>NA4926</b>	130	2.3	4.0
		<b>RNA5926</b>	<b>NA5926</b>	130	3.3	5.55
<b>RNA4828</b>			<b>NA4828</b>	140	0.98	1.9
	<b>RNA4928</b>		<b>NA4928</b>	140	2.45	4.25
		<b>RNA5928</b>	<b>NA5928</b>	140	3.55	6.0
<b>RNA4830</b>			<b>NA4830</b>	150	1.6	2.75
	<b>RNA4930</b>		<b>NA4930</b>	150	3.9	6.25
<b>RNA4832</b>			<b>NA4832</b>	160	1.75	2.95
	<b>RNA4932</b>		<b>NA4932</b>	160	4.1	6.6
<b>RNA4834</b>			<b>NA4834</b>	170	2.55	4.0
	<b>RNA4934</b>		<b>NA4934</b>	170	4.3	6.95
<b>RNA4836</b>			<b>NA4836</b>	180	2.65	4.2
	<b>RNA4936</b>		<b>NA4936</b>	180	6.2	10
<b>RNA4838</b>			<b>NA4838</b>	190	3.2	5.6
	<b>RNA4938</b>		<b>NA4938</b>	190	6.45	10.5
<b>RNA4840</b>			<b>NA4840</b>	200	3.35	5.9
	<b>RNA4940</b>		<b>NA4940</b>	200	9.7	15
<b>RNA4844</b>			<b>NA4844</b>	220	3.65	6.45
	<b>RNA4944</b>		<b>NA4944</b>	220	10	15.5
<b>RNA4848</b>			<b>NA4848</b>	240	5.45	10
	<b>RNA4948</b>		<b>NA4948</b>	240	11.5	17.5

RNA • NA

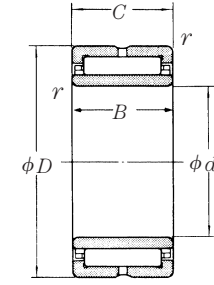
Inscribed Circle Diameter 285 — 490 mm



RNA

$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds ( $\text{min}^{-1}$ ) Oil
	$D$	$B, C$	$r_{\text{min}}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
<b>285</b>	320	60	2	395 000	1 160 000	40 000	118 000	1 400
<b>290</b>	360	100	2.1	870 000	1 910 000	88 500	194 000	1 400
<b>305</b>	350	69	2	510 000	1 390 000	52 000	142 000	1 300
<b>310</b>	380	100	2.1	905 000	2 050 000	92 500	209 000	1 300
<b>330</b>	380	80	2.1	660 000	1 810 000	67 500	185 000	1 200
<b>340</b>	420	118	3	1 150 000	2 630 000	117 000	269 000	1 200
<b>350</b>	400	80	2.1	675 000	1 900 000	69 000	194 000	1 100
<b>360</b>	440	118	3	1 190 000	2 820 000	122 000	288 000	1 100
<b>370</b>	420	80	2.1	690 000	1 990 000	70 500	203 000	1 100
<b>380</b>	460	118	3	1 240 000	3 000 000	126 000	305 000	1 100
<b>390</b>	440	80	2.1	705 000	2 080 000	72 000	212 000	1 000
<b>400</b>	480	118	3	1 280 000	3 200 000	130 000	325 000	1 000
<b>415</b>	480	100	2.1	1 030 000	2 940 000	105 000	299 000	1 000
<b>430</b>	520	140	4	1 550 000	3 750 000	158 000	385 000	950
<b>450</b>	540	140	4	1 600 000	4 000 000	164 000	410 000	900
<b>470</b>	560	140	4	1 660 000	4 250 000	170 000	435 000	900
<b>490</b>	600	160	4	1 980 000	4 750 000	202 000	485 000	850

Remarks 1. For information on inner rings, refer to page B129.  
2. If a full complement roller bearing is required, please contact NSK.

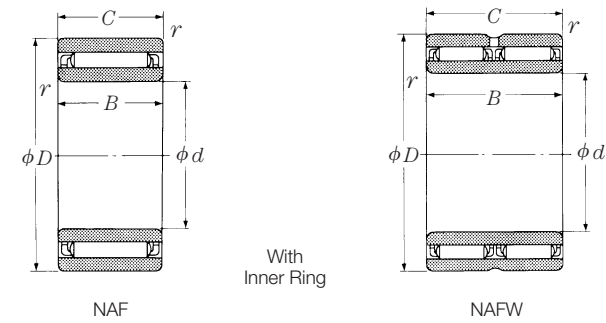
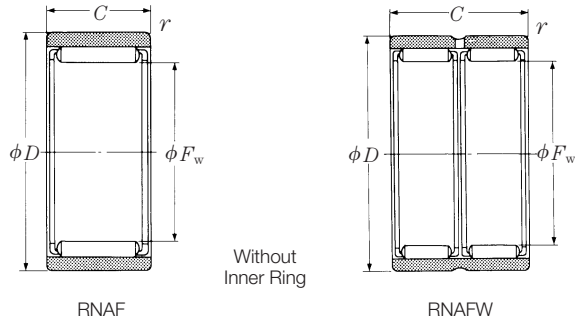


NA

Bearing Numbers				Boundary Dimensions (mm) $d$	Mass (kg) approx	
Without Inner Ring			With Inner Ring		Without Inner Ring	With Inner Ring
RNA48	RNA49	RNA59	NA			
<b>RNA4852</b>	<b>RNA4952</b>		<b>NA4852</b>	260	5.9	11
<b>RNA4856</b>				<b>NA4952</b>	260	19.5
<b>RNA4860</b>	<b>RNA4960</b>		<b>NA4856</b>	280	9.5	15.5
				<b>NA4960</b>	280	20.5
<b>RNA4864</b>	<b>RNA4964</b>		<b>NA4860</b>	300	13	22
				<b>NA4964</b>	300	30
<b>RNA4868</b>	<b>RNA4968</b>		<b>NA4864</b>	320	13.5	23.5
				<b>NA4968</b>	320	32
<b>RNA4872</b>	<b>RNA4972</b>		<b>NA4868</b>	340	14	24.5
				<b>NA4972</b>	340	33.5
<b>RNA4876</b>	<b>RNA4976</b>		<b>NA4872</b>	360	15	26
				<b>NA4976</b>	360	35.5
<b>RNA4876</b>	<b>RNA4980</b>		<b>NA4876</b>	380	25.5	42.5
				<b>NA4980</b>	380	50.5
<b>RNA4876</b>	<b>RNA4984</b>		<b>NA4972</b>	400	52.5	89
				<b>NA4984</b>	420	54.5
<b>RNA4876</b>	<b>RNA4988</b>		<b>NA4988</b>	440	81.5	125

SOLID NEEDLE ROLLER BEARINGS

- RNAF (Single-Row, Without Inner Ring)
  - RNAFW (Double-Row, Without Inner Ring)
  - NAF (Single-Row, With Inner Ring)
  - NAFW (Double-Row, With Inner Ring)
- Inscribed Circle Diameter 10 — 30 mm



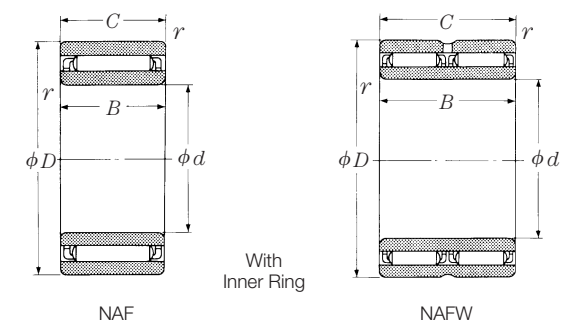
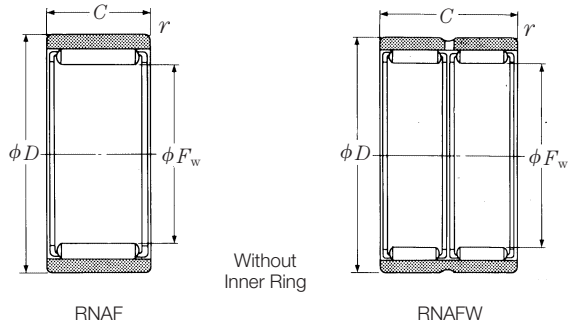
$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> ) Oil
	$D$	$C$	$r_{min}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
<b>10</b>	17	10	0.3	3 950	4 300	405	435	45 000
	20	12	0.3	7 700	6 650	785	680	48 000
<b>12</b>	22	12	0.3	9 150	8 650	935	885	38 000
<b>14</b>	22	13	0.3	8 050	9 750	820	995	32 000
	22	20	0.3	11 400	15 200	1 160	1 550	32 000
	26	12	0.3	9 850	9 800	1 010	1 000	32 000
<b>15</b>	23	13	0.3	8 400	10 500	860	1 070	28 000
	23	20	0.3	12 100	16 800	1 230	1 710	28 000
<b>16</b>	24	13	0.3	8 800	11 300	895	1 150	26 000
	24	20	0.3	12 600	18 000	1 290	1 840	26 000
	28	12	0.3	10 500	10 900	1 070	1 120	28 000
<b>17</b>	25	13	0.3	10 200	14 000	1 040	1 420	26 000
	25	20	0.3	13 100	19 300	1 340	1 970	26 000
<b>18</b>	26	13	0.3	9 450	12 900	965	1 310	24 000
	26	20	0.3	13 600	20 500	1 380	2 090	24 000
	30	12	0.3	11 700	13 000	1 190	1 320	24 000
	30	24	0.3	20 100	26 000	2 050	2 650	24 000
<b>20</b>	28	13	0.3	9 700	13 700	990	1 400	20 000
	28	26	0.3	16 600	27 500	1 690	2 800	20 000
	32	12	0.3	12 200	14 100	1 250	1 440	22 000
	32	24	0.3	20 900	28 200	2 140	2 880	22 000
<b>22</b>	30	13	0.3	10 300	15 300	1 050	1 560	19 000
	30	26	0.3	17 600	30 500	1 800	3 100	19 000
	35	16	0.3	16 600	19 500	1 700	1 980	20 000
	35	32	0.3	29 400	40 500	2 990	4 100	20 000
<b>25</b>	35	17	0.3	14 800	25 500	1 510	2 600	17 000
	35	26	0.3	19 400	36 000	1 970	3 650	17 000
	37	16	0.3	18 700	23 500	1 910	2 390	17 000
	37	32	0.3	32 000	47 000	3 250	4 800	17 000
<b>28</b>	40	16	0.3	20 200	26 800	2 060	2 730	15 000
	40	32	0.3	34 500	53 500	3 550	5 450	15 000
<b>30</b>	40	17	0.3	18 700	31 500	1 910	3 200	14 000
	40	26	0.3	24 000	43 000	2 450	4 400	14 000
	42	16	0.3	22 200	31 000	2 270	3 150	14 000
	42	32	0.3	38 000	62 000	3 900	6 300	14 000

Bearing Numbers	Boundary Dimensions (mm)		Bearing Numbers	Mass (kg)	
	$d$	$B$		Without Inner Ring	With Inner Ring
Without Inner Ring			With Inner Ring	approx	
				Without Inner Ring	With Inner Ring
<b>RNAF 101710</b>	—	—	—	0.010	—
<b>RNAF 102012</b>	—	—	—	0.018	—
<b>RNAF 122212</b>	—	—	—	0.021	—
<b>RNAF 142213</b>	10	13	<b>NAF 102213</b>	0.019	0.027
<b>RNAFW 142220</b>	10	20	<b>NAFW 102220</b>	0.030	0.042
<b>RNAF 142612</b>	10	12	<b>NAF 102612</b>	0.027	0.034
<b>RNAF 152313</b>	—	—	—	0.021	—
<b>RNAFW 152320</b>	—	—	—	0.032	—
<b>RNAF 162413</b>	12	13	<b>NAF 122413</b>	0.022	0.031
<b>RNAFW 162420</b>	12	20	<b>NAFW 122420</b>	0.034	0.048
<b>RNAF 162812</b>	12	12	<b>NAF 122812</b>	0.032	0.040
<b>RNAF 172513</b>	—	—	—	0.022	—
<b>RNAFW 172520</b>	—	—	—	0.035	—
<b>RNAF 182613</b>	—	—	—	0.024	—
<b>RNAFW 182620</b>	—	—	—	0.037	—
<b>RNAF 183012</b>	—	—	—	0.036	—
<b>RNAFW 183024</b>	—	—	—	0.072	—
<b>RNAF 202813</b>	15	13	<b>NAF 152813</b>	0.026	0.040
<b>RNAFW 202826</b>	15	26	<b>NAFW 152826</b>	0.051	0.079
<b>RNAF 203212</b>	15	12	<b>NAF 153212</b>	0.038	0.050
<b>RNAFW 203224</b>	—	—	—	0.076	—
<b>RNAF 223013</b>	17	13	<b>NAF 173013</b>	0.028	0.044
<b>RNAFW 223026</b>	17	26	<b>NAFW 173026</b>	0.056	0.087
<b>RNAF 223516</b>	17	16	<b>NAF 173516</b>	0.061	0.080
<b>RNAFW 223532</b>	17	32	<b>NAFW 173532</b>	0.12	0.16
<b>RNAF 253517</b>	20	17	<b>NAF 203517</b>	0.054	0.077
<b>RNAFW 253526</b>	20	26	<b>NAFW 203526</b>	0.080	0.115
<b>RNAF 253716</b>	20	16	<b>NAF 203716</b>	0.060	0.082
<b>RNAFW 253732</b>	20	32	<b>NAFW 203732</b>	0.12	0.16
<b>RNAF 284016</b>	—	—	—	0.067	—
<b>RNAFW 284032</b>	—	—	—	0.13	—
<b>RNAF 304017</b>	25	17	<b>NAF 254017</b>	0.064	0.092
<b>RNAFW 304026</b>	25	26	<b>NAFW 254026</b>	0.096	0.14
<b>RNAF 304216</b>	25	16	<b>NAF 254216</b>	0.069	0.095
<b>RNAFW 304232</b>	25	32	<b>NAFW 254232</b>	0.14	0.19

Remarks For information on inner rings, refer to page B129.

SOLID NEEDLE ROLLER BEARINGS

- RNAF (Single-Row, Without Inner Ring)
  - RNAFW (Double-Row, Without Inner Ring)
  - NAF (Single-Row, With Inner Ring)
  - NAFW (Double-Row, With Inner Ring)
- Inscribed Circle Diameter 35 — 100 mm



$F_w$	Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> ) Oil
	$D$	$C$	$r$ min	$C_r$	$C_{or}$	$C_r$	$C_{or}$	
<b>35</b>	45	13	0.3	14 900	24 600	1 520	2 500	12 000
	45	17	0.3	20 500	37 000	2 090	3 750	12 000
	45	26	0.3	25 600	49 000	2 610	5 000	12 000
	47	16	0.3	22 700	33 500	2 310	3 400	12 000
	47	32	0.3	39 000	66 500	3 950	6 800	12 000
<b>40</b>	50	17	0.3	21 000	40 000	2 150	4 050	10 000
	50	34	0.3	36 000	80 000	3 700	8 150	10 000
	55	20	0.3	32 500	49 500	3 300	5 050	10 000
	55	40	0.3	55 500	99 500	5 650	10 100	10 000
<b>45</b>	55	17	0.3	21 600	43 000	2 200	4 350	9 000
	55	34	0.3	37 000	85 500	3 800	8 750	9 000
	62	20	0.3	34 000	55 000	3 450	5 600	9 500
	62	40	0.3	58 000	110 000	5 950	11 200	9 500
<b>50</b>	62	20	0.3	26 900	59 000	2 750	6 050	8 000
	62	40	0.3	46 000	118 000	4 700	12 100	8 000
	65	20	0.3	38 500	67 500	3 950	6 900	8 500
	65	40	0.6	66 000	135 000	6 750	13 800	8 500
<b>55</b>	68	20	0.6	27 500	62 500	2 800	6 350	7 500
	68	40	0.6	47 000	125 000	4 800	12 700	7 500
	72	20	0.6	40 000	73 000	4 100	7 450	7 500
	72	40	0.6	68 500	146 000	7 000	14 900	7 500
<b>60</b>	78	20	1	41 500	78 000	4 200	7 950	6 700
	78	40	1	71 000	156 000	7 250	15 900	6 700
<b>65</b>	85	30	1	61 000	132 000	6 200	13 400	6 300
	85	60	1	104 000	263 000	10 600	26 800	6 300
<b>70</b>	90	30	1	63 000	140 000	6 400	14 300	6 000
	90	60	1	108 000	281 000	11 000	28 600	6 000
<b>75</b>	95	30	1	65 000	151 000	6 650	15 400	5 600
	95	60	1	112 000	300 000	11 400	31 000	5 600
<b>80</b>	100	30	1	69 000	166 000	7 050	17 000	5 000
	100	60	1	119 000	335 000	12 100	34 000	5 000
<b>85</b>	105	30	1	71 000	176 000	7 250	17 900	4 800
<b>90</b>	110	30	1	70 000	177 000	7 150	18 000	4 500
<b>95</b>	115	30	1	69 500	177 000	7 100	18 100	4 300
<b>100</b>	120	30	1	75 500	201 000	7 700	20 500	4 000

Remarks For information on inner rings, refer to page B129.

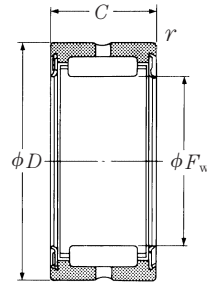
NSK NEEDLE BEARING

Bearing Numbers Without Inner Ring	Boundary Dimensions (mm)		Bearing Numbers With Inner Ring	Mass (kg) approx	
	$d$	$B$		Without Inner Ring	With Inner Ring
<b>RNAF 354513</b>	30	13	<b>NAF 304513</b>	0.053	0.078
<b>RNAF 354517</b>	30	17	<b>NAF 304517</b>	0.073	0.105
<b>RNAFW 354526</b>	30	26	<b>NAFW 304526</b>	0.105	0.155
<b>RNAF 354716</b>	30	16	<b>NAF 304716</b>	0.078	0.11
<b>RNAFW 354732</b>	30	32	<b>NAFW 304732</b>	0.16	0.22
<b>RNAF 405017</b>	35	17	<b>NAF 355017</b>	0.084	0.12
<b>RNAFW 405034</b>	35	34	<b>NAFW 355034</b>	0.165	0.24
<b>RNAF 405520</b>	35	20	<b>NAF 355520</b>	0.15	0.195
<b>RNAFW 405540</b>	35	40	<b>NAFW 355540</b>	0.295	0.385
<b>RNAF 455517</b>	40	17	<b>NAF 405517</b>	0.092	0.135
<b>RNAFW 455534</b>	40	34	<b>NAFW 405534</b>	0.18	0.265
<b>RNAF 456220</b>	40	20	<b>NAF 406220</b>	0.165	0.215
<b>RNAFW 456240</b>	40	40	<b>NAFW 406240</b>	0.325	0.43
<b>RNAF 506220</b>	45	20	<b>NAF 456220</b>	0.14	0.195
<b>RNAFW 506240</b>	45	40	<b>NAFW 456240</b>	0.28	0.395
<b>RNAF 506520</b>	—	—	—	0.175	—
<b>RNAFW 506540</b>	—	—	—	0.36	—
<b>RNAF 556820</b>	50	20	<b>NAF 506820</b>	0.165	0.23
<b>RNAFW 556840</b>	50	40	<b>NAFW 506840</b>	0.34	0.465
<b>RNAF 557220</b>	45	20	<b>NAF 457220</b>	0.225	0.345
<b>RNAFW 557240</b>	45	40	<b>NAFW 457240</b>	0.455	0.695
<b>RNAF 607820</b>	50	20	<b>NAF 507820</b>	0.265	0.40
<b>RNAFW 607840</b>	50	40	<b>NAFW 507840</b>	0.535	0.80
<b>RNAF 658530</b>	55	30	<b>NAF 558530</b>	0.495	0.71
<b>RNAFW 658560</b>	55	60	<b>NAFW 558560</b>	0.99	1.4
<b>RNAF 709030</b>	60	30	<b>NAF 609030</b>	0.53	0.765
<b>RNAFW 709060</b>	60	60	<b>NAFW 609060</b>	1.05	1.5
<b>RNAF 759530</b>	65	30	<b>NAF 659530</b>	0.575	0.825
<b>RNAFW 759560</b>	65	60	<b>NAFW 659560</b>	1.15	1.65
<b>RNAF 8010030</b>	70	30	<b>NAF 7010030</b>	0.60	0.87
<b>RNAFW 8010060</b>	70	60	<b>NAFW 7010060</b>	1.2	1.7
<b>RNAF 8510530</b>	75	30	<b>NAF 7510530</b>	0.625	0.915
<b>RNAF 9011030</b>	80	30	<b>NAF 8011030</b>	0.665	0.97
<b>RNAF 9511530</b>	85	30	<b>NAF 8511530</b>	0.695	1.0
<b>RNAF 10012030</b>	90	30	<b>NAF 9012030</b>	0.73	1.05

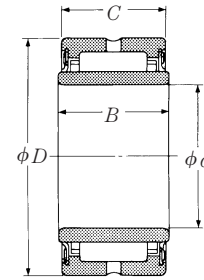
RNA...TT (Sealed, Without Inner Ring)

NA...TT (Sealed, With Inner Ring)

Inscribed Circle Diameter 14 — 52 mm



RNA...TT



NA...TT

Boundary Dimensions (mm)				Basic Load Ratings (N) {kgf}				Limiting Speeds (min <sup>-1</sup> ) Grease	Bearing Without Inner Ring
F <sub>w</sub>	D	C	r <sub>min</sub>	C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>		
14	22	13	0.3	7 350	7 500	750	765	13 000	RNA4900TT
16	24	13	0.3	8 100	8 850	825	900	11 000	RNA4901TT
	24	22	0.3	15 400	20 300	1 580	2 070	11 000	RNA6901TT
18	26	13	0.3	8 400	9 600	860	975	10 000	RNA49/14TT
20	28	13	0.3	8 700	10 300	890	1 050	9 500	RNA4902TT
	28	23	0.3	17 500	25 300	1 780	2 580	9 500	RNA6902TT
22	30	13	0.3	9 350	11 600	955	1 190	8 500	RNA4903TT
	30	23	0.3	18 800	28 500	1 920	2 910	8 500	RNA6903TT
25	37	17	0.3	16 800	18 700	1 710	1 910	7 500	RNA4904TT
	37	30	0.3	33 000	44 000	3 350	4 500	7 500	RNA6904TT
28	39	17	0.3	17 800	22 900	1 820	2 330	6 700	RNA49/22TT
	39	30	0.3	33 500	51 500	3 400	5 250	6 700	RNA69/22TT
30	42	17	0.3	19 900	24 600	2 030	2 510	6 300	RNA4905TT
	42	30	0.3	30 000	41 500	3 100	4 250	6 300	RNA6905TT
32	45	17	0.3	18 900	23 400	1 930	2 390	5 600	RNA49/28TT
	45	30	0.3	37 000	55 500	3 750	5 650	5 600	RNA69/28TT
35	47	17	0.3	20 400	26 400	2 080	2 690	5 300	RNA4906TT
	47	30	0.3	40 000	62 500	4 050	6 350	5 300	RNA6906TT
40	52	20	0.6	28 000	41 500	2 860	4 250	4 500	RNA49/32TT
	52	36	0.6	51 500	91 000	5 250	9 250	4 500	RNA69/32TT
42	55	20	0.6	29 700	45 500	3 050	4 650	4 500	RNA4907TT
	55	36	0.6	53 000	95 500	5 400	9 700	4 500	RNA6907TT
45	58	20	0.6	30 500	47 500	3 100	4 850	4 000	RNA49/38TT
48	62	22	0.6	34 500	53 500	3 550	5 450	3 800	RNA4908TT
	62	40	0.6	67 000	124 000	6 800	12 700	3 800	RNA6908TT
50	65	22	0.6	36 500	58 000	3 750	5 950	3 800	RNA49/42TT
52	68	22	0.6	36 500	58 500	3 700	5 950	3 600	RNA4909TT
	68	40	0.6	70 500	136 000	7 150	13 800	3 600	RNA6909TT

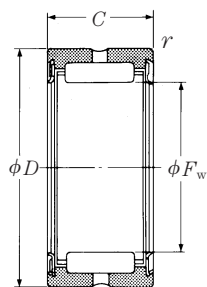
Remarks 1. For information on inner rings, refer to page B129.  
2. Standard greases is packed in sealed solid bearings unless otherwise specified.

Numbers With Inner Ring	Boundary Dimensions (mm)		Mass (kg) approx	
	d	B	Without Inner Ring	With Inner Ring
NA4900TT	10	14	0.016	0.025
NA4901TT	12	14	0.018	0.028
NA6901TT	12	23	0.030	0.046
—	—	—	0.020	—
NA4902TT	15	14	0.021	0.036
NA6902TT	15	24	0.039	0.065
NA4903TT	17	14	0.023	0.039
NA6903TT	17	24	0.041	0.069
NA4904TT	20	18	0.055	0.078
NA6904TT	20	31	0.098	0.14
NA49/22TT	22	18	0.056	0.088
NA69/22TT	22	31	0.096	0.15
NA4905TT	25	18	0.063	0.093
NA6905TT	25	31	0.11	0.165
NA49/28TT	28	18	0.076	0.10
NA69/28TT	28	31	0.13	0.18
NA4906TT	30	18	0.072	0.105
NA6906TT	30	31	0.13	0.19
NA49/32TT	32	21	0.092	0.165
NA69/32TT	32	37	0.17	0.295
NA4907TT	35	21	0.11	0.175
NA6907TT	35	37	0.20	0.32
—	—	—	0.12	—
NA4908TT	40	23	0.15	0.245
NA6908TT	40	41	0.265	0.44
—	—	—	0.17	—
NA4909TT	45	23	0.19	0.285
NA6909TT	45	41	0.335	0.50

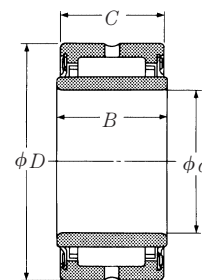
RNA...TT (Sealed, Without Inner Ring)

NA...TT (Sealed, With Inner Ring)

Inscribed Circle Diameter 55 — 125 mm



RNA...TT



NA...TT

Boundary Dimensions (mm)				Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )	Bearing
F <sub>w</sub>	D	C	r <sub>min</sub>	C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>		
<b>55</b>	70	22	0.6	38 500	63 500	3 900	6 450	3 400	<b>RNA49/48TT</b> <b>RNA4910TT</b> <b>RNA6910TT</b>
<b>58</b>	72	22	0.6	38 000	63 500	3 850	6 500	3 200	
	72	40	0.6	73 000	148 000	7 450	15 100	3 200	
<b>63</b>	80	25	1	47 500	76 000	4 850	7 750	3 000	<b>RNA4911TT</b> <b>RNA6911TT</b>
	80	45	1	90 000	172 000	9 200	17 500	3 000	
<b>68</b>	85	25	1	50 000	82 500	5 100	8 450	2 800	<b>RNA4912TT</b> <b>RNA6912TT</b>
	85	45	1	94 500	187 000	9 600	19 100	2 800	
<b>72</b>	90	25	1	52 500	89 500	5 350	9 100	2 600	<b>RNA4913TT</b> <b>RNA6913TT</b>
	90	45	1	99 000	203 000	10 100	20 700	2 600	
<b>80</b>	100	30	1	70 000	120 000	7 150	12 200	2 200	<b>RNA4914TT</b> <b>RNA6914TT</b>
	100	54	1	130 000	264 000	13 200	26 900	2 200	
<b>85</b>	105	30	1	77 000	139 000	7 850	14 100	2 200	<b>RNA4915TT</b> <b>RNA6915TT</b>
	105	54	1	136 000	286 000	13 800	29 100	2 200	
<b>90</b>	110	30	1	76 500	139 000	7 800	14 200	2 000	<b>RNA4916TT</b> <b>RNA6916TT</b>
	110	54	1	141 000	305 000	14 400	31 500	2 000	
<b>100</b>	120	35	1.1	94 500	189 000	9 600	19 300	1 900	<b>RNA4917TT</b> <b>RNA6917TT</b>
	120	63	1.1	167 000	395 000	17 100	40 000	1 900	
<b>105</b>	125	35	1.1	98 000	201 000	10 000	20 500	1 800	<b>RNA4918TT</b> <b>RNA6918TT</b>
	125	63	1.1	173 000	420 000	17 700	43 000	1 800	
<b>110</b>	130	35	1.1	101 000	214 000	10 300	21 800	1 700	<b>RNA4919TT</b> <b>RNA6919TT</b>
	130	63	1.1	181 000	450 000	18 500	46 000	1 700	
<b>115</b>	140	40	1.1	131 000	261 000	13 400	26 600	1 600	<b>RNA4920TT</b>
<b>125</b>	150	40	1.1	136 000	279 000	13 800	28 500	1 500	<b>RNA4922TT</b>

**Remarks** 1. For information on inner rings, refer to page B129.  
2. Standard greases is packed in sealed solid bearings unless otherwise specified.

Numbers	Boundary Dimensions (mm)		Mass (kg)	
	With Inner Ring	d	Without Inner Ring	With Inner Ring
—	—	—	0.18	—
<b>NA4910TT</b>	50	23	0.18	0.30
<b>NA6910TT</b>	50	41	0.32	0.535
<b>NA4911TT</b>	55	26	0.26	0.405
<b>NA6911TT</b>	55	46	0.475	0.735
<b>NA4912TT</b>	60	26	0.28	0.44
<b>NA6912TT</b>	60	46	0.485	0.765
<b>NA4913TT</b>	65	26	0.32	0.47
<b>NA6913TT</b>	65	46	0.53	0.795
<b>NA4914TT</b>	70	31	0.47	0.75
<b>NA6914TT</b>	70	55	0.89	1.4
<b>NA4915TT</b>	75	31	0.50	0.80
<b>NA6915TT</b>	75	55	0.96	1.5
<b>NA4916TT</b>	80	31	0.53	0.845
<b>NA6916TT</b>	80	55	0.99	1.55
<b>NA4917TT</b>	85	36	0.68	1.25
<b>NA6917TT</b>	85	64	1.2	2.25
<b>NA4918TT</b>	90	36	0.72	1.35
<b>NA6918TT</b>	90	64	1.35	2.45
<b>NA4919TT</b>	95	36	0.74	1.4
<b>NA6919TT</b>	95	64	1.5	2.65
<b>NA4920TT</b>	100	41	1.15	1.95
<b>NA4922TT</b>	110	41	1.25	2.1

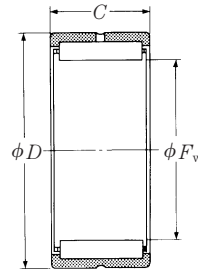


SOLID NEEDLE ROLLER BEARINGS (INCH DESIGN)

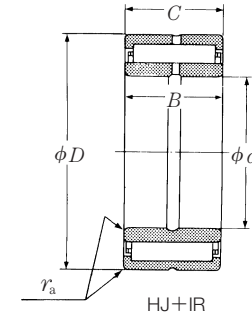
HJ (Single-Row, Without Inner Ring)

HJ + IR (Single-Row, With Inner Ring)

Inscribed Circle Diameter 15.875 — 44.450 mm



HJ



HJ+IR

\* Fillet Radius of Shaft, Housing

$F_w$	Boundary Dimensions (mm, inch)				Basic Load Ratings {kgf}				Limiting Speeds (min <sup>-1</sup> ) Oil	
	$D$	$C$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$		
<b>15.875</b>	0.6250	28.575	1.1250	19.05	0.7500	18 600	19 400	1 890	1 980	30 000
<b>19.050</b>	0.7500	31.750	1.2500	19.05	0.7500	19 800	21 900	2 020	2 230	24 000
		31.750	1.2500	25.40	1.0000	26 800	32 000	2 730	3 300	24 000
<b>22.225</b>	0.8750	34.925	1.3750	19.05	0.7500	22 100	26 200	2 260	2 670	20 000
		34.925	1.3750	25.40	1.0000	29 900	38 500	3 050	3 950	20 000
<b>25.400</b>	1.0000	38.100	1.5000	19.05	0.7500	24 200	30 500	2 470	3 100	17 000
		38.100	1.5000	25.40	1.0000	32 500	45 000	3 350	4 600	17 000
<b>28.575</b>	1.1250	41.275	1.6250	25.40	1.0000	35 500	51 500	3 600	5 250	15 000
		41.275	1.6250	31.75	1.2500	44 000	68 000	4 500	6 950	15 000
<b>31.750</b>	1.2500	44.450	1.7500	25.40	1.0000	36 500	55 000	3 700	5 600	13 000
		44.450	1.7500	31.75	1.2500	45 500	72 500	4 600	7 400	13 000
<b>34.925</b>	1.3750	47.625	1.8750	25.40	1.0000	38 500	61 000	3 950	6 250	12 000
		47.625	1.8750	31.75	1.2500	48 000	81 000	4 900	8 250	12 000
<b>38.100</b>	1.5000	52.388	2.0625	25.40	1.0000	46 000	68 500	4 650	7 000	11 000
		52.388	2.0625	31.75	1.2500	57 000	91 000	5 850	9 300	11 000
<b>41.275</b>	1.6250	55.562	2.1875	25.40	1.0000	47 000	72 500	4 800	7 400	10 000
		55.562	2.1875	31.75	1.2500	58 500	96 500	6 000	9 850	10 000
<b>44.450</b>	1.7500	58.738	2.3125	25.40	1.0000	48 000	76 500	4 900	7 800	9 500
		58.738	2.3125	31.75	1.2500	60 000	102 000	6 150	10 400	9 500

- Remarks**
- For bearings with inner rings, the inner ring number is written separately from the Bearing number.  
Example: HJ-202816 + IR-162016
  - If a full complement roller bearing is required, please contact NSK.

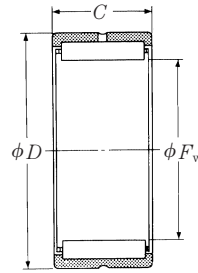
Bearing Numbers	Boundary Dimensions (mm, inch)				Matching Inner Rings	* (mm) $r_a$ max	Mass (kg)	
	$d$	$B$	Without Inner Ring	With Inner Ring				
<b>HJ-101812</b>	9.525	0.3750	19.05	0.7500	<b>IR-061012</b>	0.6	0.050	0.068
<b>HJ-122012</b>	12.700	0.5000	19.05	0.7500	<b>IR-081212</b>	1	0.054	0.081
	12.700	0.5000	25.40	1.0000		1	0.073	0.11
<b>HJ-142212</b>	15.875	0.6250	19.05	0.7500	<b>IR-101412</b>	1	0.064	0.090
	17.462	0.6875	19.05	0.7500		1	0.064	0.087
<b>HJ-142216</b>	15.875	0.6250	25.40	1.0000	<b>IR-101416</b>	1	0.082	0.115
<b>HJ-162412</b>	19.050	0.7500	19.05	0.7500	<b>IR-121612</b>	1	0.068	0.10
	19.050	0.7500	25.40	1.0000		1	0.091	0.135
<b>HJ-162416</b>	20.638	0.8125	25.40	1.0000	<b>IR-131616</b>	1	0.091	0.125
<b>HJ-182616</b>	22.225	0.8750	25.40	1.0000	<b>IR-141816</b>	1	0.10	0.15
	23.812	0.9375	25.40	1.0000		1	0.10	0.14
<b>HJ-182620</b>	22.225	0.8750	31.75	1.2500	<b>IR-151816</b>	1	0.13	0.195
	23.812	0.9375	31.75	1.2500		1	0.13	0.18
<b>HJ-202816</b>	25.400	1.0000	25.40	1.0000	<b>IR-162016</b>	1	0.11	0.17
	25.400	1.0000	31.75	1.2500		1	0.14	0.215
<b>HJ-223016</b>	28.575	1.1250	25.40	1.0000	<b>IR-182216</b>	1	0.12	0.185
	28.575	1.1250	31.75	1.2500		1	0.155	0.23
<b>HJ-243316</b>	31.750	1.2500	25.40	1.0000	<b>IR-202416</b>	1.5	0.155	0.23
	30.162	1.1875	31.75	1.2500		1.5	0.195	0.30
<b>HJ-243320</b>	31.750	1.2500	31.75	1.2500	<b>IR-192420</b>	1.5	0.195	0.285
<b>HJ-263516</b>	33.338	1.3125	25.40	1.0000	<b>IR-212616</b>	1.5	0.16	0.255
	33.338	1.3125	31.75	1.2500		1.5	0.20	0.32
<b>HJ-263520</b>	34.925	1.3750	31.75	1.2500	<b>IR-222620</b>	1.5	0.20	0.30
<b>HJ-283716</b>	36.512	1.4375	25.40	1.0000	<b>IR-232816</b>	1.5	0.17	0.27
	38.100	1.5000	25.40	1.0000		1.5	0.17	0.265
<b>HJ-283720</b>	34.925	1.3750	31.75	1.2500	<b>IR-242816</b>	1.5	0.215	0.36
	36.512	1.4375	31.75	1.2500		1.5	0.215	0.34
	38.100	1.5000	31.75	1.2500	<b>IR-222820</b>	1.5	0.215	0.34
					<b>IR-232820</b>	1.5	0.215	0.34
					<b>IR-242820</b>	1.5	0.215	0.315

SOLID NEEDLE ROLLER BEARINGS (INCH DESIGN)

HJ (Single-Row, Without Inner Ring)

HJ + IR (Single-Row, With Inner Ring)

Inscribed Circle Diameter 47.625 — 101.600 mm

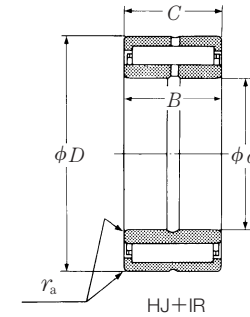


HJ

$F_w$	Boundary Dimensions (mm, inch)					Basic Load Ratings (N) {kgf}				Limiting Speeds (min <sup>-1</sup> ) Oil
	$D$	$C$	$C_r$	$C_{or}$	$C_r$	$C_{or}$	$C_r$	$C_{or}$		
<b>47.625</b>	1.8750	61.912	2.4375	31.75	1.2500	63 500	112 000	6 500	11 400	9 000
<b>50.800</b>	2.0000	65.088	2.5625	25.40	1.0000	52 000	88 000	5 300	9 000	8 500
		65.088	2.5625	31.75	1.2500	65 000	117 000	6 600	12 000	8 500
<b>57.150</b>	2.2500	76.200	3.0000	38.10	1.5000	89 000	161 000	9 100	16 400	7 500
		76.200	3.0000	44.45	1.7500	103 000	194 000	10 500	19 800	7 500
<b>63.500</b>	2.5000	82.550	3.2500	38.10	1.5000	96 000	183 000	9 800	18 700	6 700
		82.550	3.2500	44.45	1.7500	111 000	221 000	11 300	22 600	6 700
<b>69.850</b>	2.7500	88.900	3.5000	25.40	1.0000	66 000	116 000	6 700	11 800	6 000
		88.900	3.5000	38.10	1.5000	100 000	199 000	10 200	20 300	6 000
		88.900	3.5000	44.45	1.7500	116 000	240 000	11 800	24 500	6 000
<b>76.200</b>	3.0000	95.250	3.7500	38.10	1.5000	106 000	221 000	10 800	22 600	5 600
		95.250	3.7500	44.45	1.7500	123 000	268 000	12 600	27 300	5 600
<b>82.550</b>	3.2500	107.950	4.2500	44.45	1.7500	161 000	300 000	16 400	30 500	5 000
		107.950	4.2500	50.80	2.0000	182 000	350 000	18 600	36 000	5 000
<b>88.900</b>	3.5000	114.300	4.5000	50.80	2.0000	186 000	370 000	18 900	37 500	4 800
<b>95.250</b>	3.7500	120.650	4.7500	50.80	2.0000	194 000	400 000	19 800	40 500	4 500
<b>101.600</b>	4.0000	127.000	5.0000	50.80	2.0000	202 000	430 000	20 600	43 500	4 000

- Remarks**
- For bearings with inner rings, the inner ring number is written separately from the Bearing number.  
Example: HJ-202816 + IR-162016
  - If a full complement roller bearing is required, please contact NSK.

NSK NEEDLE BEARING



HJ+IR

\* Fillet Radius of Shaft, Housing

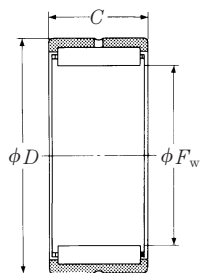
Bearing Numbers	Boundary Dimensions (mm, inch)				Matching Inner Rings	* (mm) $r_a$ max	Mass (kg)	
	$d$	$B$	$C$	$D$			approx Without Inner Ring	With Inner Ring
<b>HJ-303920</b>	39.688	1.5625	31.75	1.2500	<b>IR-253020</b>	1.5	0.225	0.36
<b>HJ-324116</b>	42.862	1.6875	25.40	1.0000	<b>IR-273216</b>	1.5	0.185	0.305
<b>HJ-324120</b>	38.100	1.5000	31.75	1.2500	<b>IR-243220</b>	1.5	0.235	0.455
	39.688	1.5625	31.75	1.2500	<b>IR-253220</b>	1.5	0.235	0.43
	41.275	1.6250	31.75	1.2500	<b>IR-263220</b>	1.5	0.235	0.405
	42.862	1.6875	31.75	1.2500	<b>IR-273220</b>	1.5	0.235	0.38
<b>HJ-364824</b>	44.450	1.7500	38.10	1.5000	<b>IR-283624</b>	1.5	0.45	0.755
<b>HJ-364828</b>	44.450	1.7500	44.45	1.7500	<b>IR-283628</b>	1.5	0.525	0.88
<b>HJ-405224</b>	49.212	1.9375	38.10	1.5000	<b>IR-314024</b>	2	0.525	0.90
	50.800	2.0000	38.10	1.5000	<b>IR-324024</b>	2	0.525	0.865
<b>HJ-405228</b>	49.212	1.9375	44.45	1.7500	<b>IR-314028</b>	2	0.575	1.0
	50.800	2.0000	44.45	1.7500	<b>IR-324028</b>	2	0.575	0.975
<b>HJ-445616</b>	—	—	—	—	—	2	0.485	—
<b>HJ-445624</b>	57.150	2.2500	38.10	1.5000	<b>IR-364424</b>	2	0.595	0.97
<b>HJ-445628</b>	55.562	2.1875	44.45	1.7500	<b>IR-354428</b>	2	0.65	1.15
	57.150	2.2500	44.45	1.7500	<b>IR-364428</b>	2	0.65	1.1
<b>HJ-486024</b>	63.500	2.5000	38.10	1.5000	<b>IR-404824</b>	2	0.61	1.05
<b>HJ-486028</b>	60.325	2.3750	44.45	1.7500	<b>IR-384828</b>	2	0.68	1.25
	63.500	2.5000	44.45	1.7500	<b>IR-404828</b>	2	0.68	1.15
<b>HJ-526828</b>	69.850	2.7500	44.45	1.7500	<b>IR-445228</b>	2	1.05	1.55
<b>HJ-526832</b>	69.850	2.7500	50.80	2.0000	<b>IR-445232</b>	2	1.2	1.8
<b>HJ-567232</b>	74.612	2.9375	50.80	2.0000	<b>IR-475632</b>	2	1.2	1.95
	76.200	3.0000	50.80	2.0000	<b>IR-485632</b>	2	1.2	1.9
<b>HJ-607632</b>	79.375	3.1250	50.80	2.0000	<b>IR-506032</b>	2.5	1.3	2.2
	82.550	3.2500	50.80	2.0000	<b>IR-526032</b>	2.5	1.3	2.0
<b>HJ-648032</b>	82.550	3.2500	50.80	2.0000	<b>IR-526432</b>	2.5	1.4	2.5
	85.725	3.3750	50.80	2.0000	<b>IR-546432</b>	2.5	1.4	2.3
	88.900	3.5000	50.80	2.0000	<b>IR-566432</b>	2.5	1.4	2.15

SOLID NEEDLE ROLLER BEARINGS (INCH DESIGN)

HJ (Single-Row, Without Inner Ring)

HJ + IR (Single-Row, With Inner Ring)

Inscribed Circle Diameter 107.950 — 234.950 mm

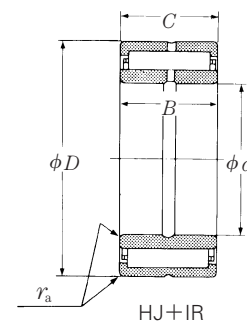


HJ

	Boundary Dimensions (mm, inch)					Basic Load Ratings (N) {kgf}				Limiting Speeds (min <sup>-1</sup> ) Oil
	F <sub>w</sub>	D		C		C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>	
<b>107.950</b>	4.2500	133.350	5.2500	50.80	2.0000	205 000	445 000	20 900	45 500	3 800
<b>114.300</b>	4.5000	152.400	6.0000	57.15	2.2500	290 000	525 000	29 600	53 500	3 800
		152.400	6.0000	63.50	2.5000	325 000	600 000	33 000	61 500	3 800
<b>127.000</b>	5.0000	165.100	6.5000	50.80	2.0000	279 000	515 000	28 400	52 500	3 400
		165.100	6.5000	57.15	2.2500	315 000	600 000	32 000	61 000	3 400
		165.100	6.5000	63.50	2.5000	350 000	685 000	35 500	70 000	3 400
<b>139.700</b>	5.5000	177.800	7.0000	63.50	2.5000	350 000	715 000	36 000	73 000	3 000
		177.800	7.0000	76.20	3.0000	415 000	890 000	42 500	91 000	3 000
<b>146.050</b>	5.7500	184.150	7.2500	76.20	3.0000	425 000	925 000	43 500	94 500	2 800
<b>152.400</b>	6.0000	190.500	7.5000	63.50	2.5000	375 000	795 000	38 000	81 500	2 800
		190.500	7.5000	76.20	3.0000	445 000	995 000	45 000	101 000	2 800
<b>165.100</b>	6.5000	203.200	8.0000	63.50	2.5000	385 000	855 000	39 500	87 000	2 400
		203.200	8.0000	76.20	3.0000	460 000	1 060 000	46 500	109 000	2 400
<b>184.150</b>	7.2500	231.775	9.1250	76.20	3.0000	535 000	1 140 000	54 500	117 000	2 200
<b>196.850</b>	7.7500	244.475	9.6250	76.20	3.0000	555 000	1 230 000	56 500	125 000	2 000
<b>209.550</b>	8.2500	257.175	10.1250	76.20	3.0000	575 000	1 310 000	58 500	133 000	2 000
<b>222.250</b>	8.7500	269.875	10.6250	76.20	3.0000	590 000	1 390 000	60 500	142 000	1 900
		282.575	11.1250	76.20	3.0000	610 000	1 470 000	62 000	150 000	1 800

**Remarks** 1. For bearings with inner rings, the inner ring number is written separately from the Bearing number.  
Example: HJ-202816 + IR-162016  
2. If a full complement roller bearing is required, please contact NSK.

NSK NEEDLE BEARING



HJ+IR

\* Fillet Radius of Shaft, Housing

Bearing Numbers	Boundary Dimensions (mm, inch)				Matching Inner Rings	* (mm) r <sub>a</sub> max	Mass (kg)	
	Without Inner Ring		With Inner Ring				Without Inner Ring	With Inner Ring
<b>HJ-688432</b>	88.900	3.5000	50.80	2.0000	<b>IR-566832</b> <b>IR-606832</b>	2.5	1.5	2.65
	95.250	3.7500	50.80	2.0000		2.5	1.5	2.5
<b>HJ-729636</b> <b>HJ-729640</b>	95.250	3.7500	57.15	2.2500	<b>IR-607236</b> <b>IR-607240</b>	2.5	2.75	4.15
	95.250	3.7500	63.50	2.5000		2.5	3.05	4.6
<b>HJ-8010432</b> <b>HJ-8010436</b>	—	—	—	—	<b>IR-648036</b> <b>IR-688036</b>	2.5	2.4	—
	101.600	4.0000	57.15	2.2500		2.5	2.9	4.95
<b>HJ-8010440</b>	107.950	4.2500	57.15	2.2500	<b>IR-648040</b>	2.5	2.9	4.45
	101.600	4.0000	63.50	2.5000		2.5	3.3	5.55
<b>HJ-8811240</b> <b>HJ-8811248</b>	114.300	4.5000	63.50	2.5000	<b>IR-728840</b> <b>IR-728848</b>	2.5	3.6	6.1
	114.300	4.5000	76.20	3.0000		2.5	4.25	7.2
<b>HJ-9211648</b>	120.650	4.7500	76.20	3.0000	<b>IR-769248</b>	3	4.55	7.7
	<b>HJ-9612040</b> <b>HJ-9612048</b>	127.000	5.0000	63.50		2.5000	3	3.9
<b>HJ-10412840</b> <b>HJ-10412848</b>	127.000	5.0000	76.20	3.0000	<b>IR-809640</b> <b>IR-809648</b>	3	4.75	8.1
	139.700	5.5000	63.50	2.5000		3	4.15	7.2
<b>HJ-11614648</b> <b>HJ-12415448</b> <b>HJ-13216248</b>	139.700	5.5000	76.20	3.0000	<b>IR-8810440</b> <b>IR-8810448</b>	3	4.75	8.4
	152.400	6.0000	76.20	3.0000		3	7.1	12
165.100	6.5000	76.20	3.0000	3		7.5	13	
<b>HJ-14017048</b> <b>HJ-14817848</b>	177.800	7.0000	76.20	3.0000	<b>IR-11213248</b>	3	7.95	13.5
	190.500	7.5000	76.20	3.0000		4	8.35	14.5
	203.200	8.0000	76.20	3.0000	<b>IR-12014048</b> <b>IR-12814048</b>	4	8.6	15

**INNER RINGS FOR NEEDLE ROLLER BEARINGS**

**DRAWN CUP TYPE**

Pages

Metric Design (FIR)	Bore Diameter	7–45 mm .....	B130–B135
Inch Design (IR)	Bore Diameter	9.525–38.100 mm .....	B136–B137

**SOLID TYPE**

Metric Design (FIR)	Bore Diameter	5–220 mm .....	B138–B151
Metric Design (FIR)	Bore Diameter	8–50 mm .....	B152–B155
Inch Design (IR)	Bore Diameter	9.525–203.200 mm .....	B156–B161

For use when shafts cannot be finished with proper accuracy and hardness, NSK produces inner rings that are made from carefully selected bearing steel and finished with heat treatment and grinding work.

**TYPE**

The various types of inner rings for needle roller bearings are shown in **Table 1**.

**ACCURACY**

Dimensional accuracy of the inner rings of NSK needle roller bearings conforms with ISO (refer to pages A26 and A27). Tolerances for inch inner rings are shown in the dimensional table for drawn cup bearings, and in **Table 3** on page B92 for solid bearings.

**Table 1 Types of Inner Ring**

Code	Details
FIR	Metric needle bearing combination
IR	Inch needle bearing combination

**MOUNTING**

The inner ring is mounted with the unmarked side placed onto the shaft shoulder.

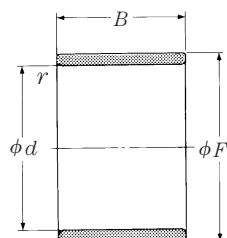
Fitting tolerance for the drawn cup needle bearing shaft should be h6 or js6 (j6). When requesting a tight fit for the inner ring, please consult NSK.

Each shaft fitting tolerance for the inner ring for solid needle bearings is shown in **Table 5.2** on page A33.



FIR

Bore Diameter 7 — 15 mm

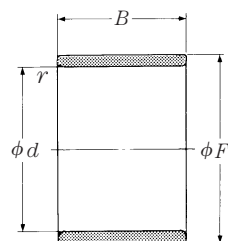


$d$	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (g) approx
	$F$ h5	$B$	$r$ min		
<b>7</b>	10	10.5	0.3	<b>FIR-071010</b>	3.3
	10	12.5	0.3	<b>FIR-071012</b>	3.9
	10	12.5	0.3	<b>FIR-071015</b>	4.8
<b>8</b>	12	10.5	0.3	<b>FIR-081210</b>	5.1
	12	12.5	0.3	<b>FIR-081212</b>	6.1
	12	15.5	0.3	<b>FIR-081215</b>	7.6
<b>10</b>	13	12.5	0.3	<b>FIR-101312</b>	5.3
	14	12.5	0.3	<b>FIR-101412</b>	7.3
	14	13.5	0.3	<b>FIR-101413</b>	7.9
	14	16.5	0.3	<b>FIR-101416</b>	9.7
	14	20.5	0.3	<b>FIR-101420</b>	12
	15	10.5	0.3	<b>FIR-101510</b>	8.0
	15	12.5	0.3	<b>FIR-101512</b>	9.5
	15	15.5	0.3	<b>FIR-101515</b>	12
	15	20.5	0.3	<b>FIR-101520</b>	16
	15	25.5	0.3	<b>FIR-101525</b>	19
<b>12</b>	15	12.5	0.3	<b>FIR-121512</b>	6.2
	15	16.5	0.3	<b>FIR-121516</b>	8.2
	16	12.5	0.3	<b>FIR-121612</b>	8.6
	16	16.5	0.3	<b>FIR-121616</b>	11
	16	20.5	0.3	<b>FIR-121620</b>	14
	17	15.5	0.3	<b>FIR-121715</b>	14
	17	20.5	0.3	<b>FIR-121720</b>	18
	17	25.5	0.3	<b>FIR-121725</b>	23
<b>15</b>	18	12.5	0.3	<b>FIR-151812</b>	7.6
	18	15.5	0.3	<b>FIR-151815</b>	9.4
	18	16.5	0.3	<b>FIR-151816</b>	10
	18	20.5	0.3	<b>FIR-151820</b>	12
	18	25.5	0.3	<b>FIR-151825</b>	15
	20	15.5	0.3	<b>FIR-152015</b>	17
	20	20.5	0.3	<b>FIR-152020</b>	22
	20	25.5	0.3	<b>FIR-152025</b>	27
	20	30.5	0.3	<b>FIR-152030</b>	33

Matching Drawn Cup Needle Roller Bearings		
F	FJ	FJL
FH-1010	FJ-1010	FJL-1010
—	—	FJL-1012L
—	FJ-1015	FJL-1015
—	FJ-1210	—
FJ-1212	FJH-1212	FJL-1212L
—	—	FJL-1215
F-1312	FJ-1312	—
F-1412	FJ-1412	—
F-1413	—	—
—	—	FJL-1416L
—	—	FJL-1420L
—	—	FJL-1510L
F-1512	FJ-1512	FJL-1512L
—	—	FJL-1515
—	—	FJL-1520
—	—	FJL-1525L
F-1512	FJ-1512	FJL-1512L
F-1516	FJ-1516	—
F-1612	FJ-1612	—
F-1616	FJ-1616	FJL-1616L
—	—	FJL-1620L
—	—	FJL-1715
—	—	FJL-1720L
—	—	FJL-1725L
F-1812	FJ-1812	—
—	—	FJL-1815
F-1816	FJ-1816	—
—	—	FJL-1820L
—	—	FJL-1825
—	—	FJL-2015
F-2020	FJ-2020	FJL-2020
—	—	FJL-2025L
—	—	FJL-2030L

FIR

Bore Diameter 17 — 30 mm

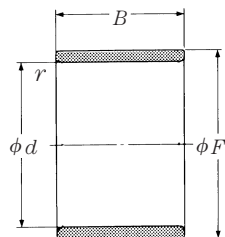


d	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (g) approx
	F h5	B	r min		
17	20	12.5	0.3	<b>FIR-172012</b>	8.5
	20	16.5	0.3	<b>FIR-172016</b>	11
	20	20.5	0.3	<b>FIR-172020</b>	14
	22	10.5	0.3	<b>FIR-172210</b>	12
	22	12.5	0.3	<b>FIR-172212</b>	15
	22	15.5	0.3	<b>FIR-172215</b>	18
	22	16.5	0.3	<b>FIR-172216</b>	20
	22	20.5	0.3	<b>FIR-172220</b>	24
	22	25.5	0.3	<b>FIR-172225</b>	30
	22	30.5	0.3	<b>FIR-172230</b>	36
20	25	10.5	0.3	<b>FIR-202510</b>	14
	25	15.5	0.3	<b>FIR-202515</b>	21
	25	16.5	0.3	<b>FIR-202516</b>	23
	25	20.5	0.3	<b>FIR-202520</b>	28
	25	25.5	0.3	<b>FIR-202525</b>	35
	25	26.5	0.3	<b>FIR-202526</b>	36
	25	30.5	0.3	<b>FIR-202530</b>	42
22	28	16.5	0.3	<b>FIR-222816</b>	30
	28	20.5	0.3	<b>FIR-222820</b>	38
	28	26.5	0.3	<b>FIR-222826</b>	49
	28	30.5	0.3	<b>FIR-222830</b>	56
25	30	15.5	0.3	<b>FIR-253015</b>	26
	30	20.5	0.3	<b>FIR-253020</b>	34
	30	25.5	0.3	<b>FIR-253026</b>	43
	30	26.5	0.3	<b>FIR-253026</b>	44
	30	30.5	0.3	<b>FIR-253030</b>	51
	30	30.5	0.3	<b>FIR-253030</b>	51
28	32	20.5	0.3	<b>FIR-283220</b>	30
	32	30.5	0.3	<b>FIR-283230</b>	45
30	35	12.5	0.6	<b>FIR-303512</b>	25
	35	15.5	0.6	<b>FIR-303515</b>	31
	35	20.5	0.6	<b>FIR-303520</b>	41
	35	25.5	0.6	<b>FIR-303525</b>	51
	35	26.5	0.6	<b>FIR-303526</b>	53
	35	30.5	0.6	<b>FIR-303530</b>	61

Matching Drawn Cup Needle Roller Bearings		
F	FJ	FJL
F-2012	FJ-2012	—
F-2016	FJ-2016	—
F-2020	FJ-2020	FJL-2020
F-2210	—	FJL-2210L
F-2212	FJ-2212	—
—	—	FJL-2215L
F-2216	FJ-2216	—
F-2220	FJ-2220	FJL-2220L
—	—	FJL-2225L
—	—	FJL-2230L
—	—	FJL-2510
—	—	FJL-2515L
F-2516	FJ-2516	—
F-2520	FJ-2520	FJL-2520
—	—	FJL-2525L
F-2526	FJ-2526	—
—	—	FJL-2530
F-2816	FJ-2816	—
F-2820	FJ-2820	FJL-2820L
F-2826	FJ-2826	—
—	—	FJL-2830L
—	—	FJL-3015L
F-3020	FJ-3020	FJL-3020L
—	—	FJL-3025L
F-3026	FJ-3026	—
—	—	FJL-3030L
—	—	FJL-3220
—	—	FJL-3230
F-3512	FJ-3512	FJL-3512
—	—	FJL-3515
F-3520	FJ-3520	FJL-3520L
—	—	FJL-3525L
F-3526	FJ-3526	—
—	—	FJL-3530L

FIR

Bore Diameter 35 — 45 mm

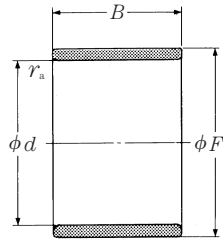


$d$	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (g) approx
	$F$ h5	$B$	$r$ min		
<b>35</b>	40	15.5	0.6	<b>FIR-354015</b>	36
	40	20.5	0.6	<b>FIR-354020</b>	47
	40	25.5	0.6	<b>FIR-354025</b>	58
	40	26.5	0.6	<b>FIR-354026</b>	61
	40	30.5	0.6	<b>FIR-354030</b>	70
	<b>40</b>	45	20.5	0.6	<b>FIR-404520</b>
45		25.5	0.6	<b>FIR-404525</b>	66
45		26.5	0.6	<b>FIR-404526</b>	67
45		30.5	0.6	<b>FIR-404530</b>	79
<b>45</b>		50	12.5	0.6	<b>FIR-455012</b>
	50	15.5	0.6	<b>FIR-455015</b>	45
	50	20.5	0.6	<b>FIR-455020</b>	59
	50	25.5	0.6	<b>FIR-455025</b>	74
	50	30.5	0.6	<b>FIR-455030</b>	89

Matching Drawn Cup Needle Roller Bearings		
F	FJ	FJL
—	—	FJL-4015L
F-4020	FJ-4020	FJL-4020L
—	—	FJL-4025L
F-4026	FJ-4026	—
—	—	FJL-4030L
F-4520	FJ-4520	FJL-4520L
—	—	FJL-4525L
F-4526	FJ-4526	—
—	—	FJL-4530L
—	—	FJL-5012L
—	—	FJL-5015L
—	FJ-5020	FJL-5020L
—	—	FJL-5025L
—	—	FJL-5030L

IR

Bore Diameter 9.525 — 38.100 mm



d 0 -0.013	Boundary Dimensions (mm, inch)			Inner Ring Numbers	Mass (g) approx	Fillet Radius of Shaft (mm) r <sub>a</sub> max	
	F 0 -0.013	B 0 -0.25					
9.525	0.3750	14.288	0.5625	13.08	IR-68 IR-68-1 IR-612 IR-612-1	9.1 13 13 19	0.6 0.6 0.6 0.6
		15.875	0.6250	13.08			
		14.288	0.5625	19.43			
		15.875	0.6250	19.43			
12.700	0.5000	19.050	0.7500	13.08	IR-88 IR-812	16 24	1.0 1.0
		19.050	0.7500	19.43			
15.875	0.6250	22.225	0.8750	19.43	IR-1012 IR-1016	29 38	1.0 1.0
		22.225	0.8750	25.78			
19.050	0.7500	25.400	1.0000	13.08	IR-128 IR-1212 IR-1216	23 34 44	1.0 1.0 1.0
		25.400	1.0000	19.43			
		25.400	1.0000	25.78			
20.638	0.8125	25.400	1.0000	32.13	IR-1220 IR-1224	55 66	1.0 1.0
		25.400	1.0000	38.48			
22.225	0.8750	28.575	1.1250	25.78	IR-1416 IR-1516	51 39	1.0 1.0
		28.575	1.1250	25.78			
23.812	0.9375	28.575	1.1250	25.78	IR-1612 IR-1616	43 57	1.0 1.0
		31.750	1.1250	19.42			
25.400	1.0000	31.750	1.1250	25.78	IR-1616	57	1.0
		31.750	1.1250	25.78			
28.575	1.1250	34.925	1.3750	19.43	IR-1812 IR-1816 IR-1820	48 64 79	1.0 1.0 1.0
		34.925	1.3750	25.78			
		34.925	1.3750	32.13			
30.162	1.1875	38.100	1.5000	25.78	IR-1916 IR-1920	85 105	1.0 1.0
		38.100	1.5000	32.13			
31.750	1.2500	38.100	1.5000	25.78	IR-2016 IR-2020	70 87	1.5 1.5
		38.100	1.5000	32.13			
34.925	1.3750	41.275	1.6250	32.13	IR-2220	95	1.5
36.512	1.4375	44.450	1.7500	25.78	IR-2316 IR-2324	100 150	1.5 1.5
		44.450	1.7500	38.48			
38.100	1.5000	44.450	1.7500	25.78	IR-2416 IR-2424	83 125	1.5 1.5
		44.450	1.7500	38.48			

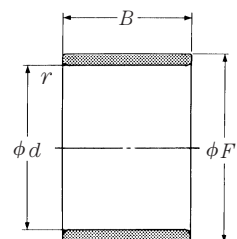
Matching Drawn Cup Needle Roller Bearings			
B	BH	J	JH
B-98	BH-98	J-98	JH-98
B-108	BH-108	J-108	—
B-912	BH-912	—	—
B-1012	BH-1012	J-1012	—
B-128	—	J-128	—
B-1212	—	J-1212	JH-1212
B-1412	BH-1412	J-1412	JH-1412
B-1416	—	J-1416	JH-1416
B-168	BH-168	—	—
B-1612	BH-1612	J-1612	JH-1612
B-1616	BH-1616	J-1616	JH-1616
—	BH-1620	—	—
—	BH-1624	—	—
B-1612	BH-1612	J-1612	JH-1612
B-1616	BH-1616	J-1616	JH-1616
B-1816	BH-1816	J-1816	JH-1816
B-1816	BH-1816	J-1816	JH-1816
B-2012	BH-2012	J-2012	—
B-2016	BH-2016	J-2016	JH-2016
B-2212	BH-2212	—	JH-2212
B-2216	BH-2216	—	JH-2216
B-2220	BH-2220	—	—
B-2416	—	J-2416	—
B-2420	—	J-2420	—
B-2416	—	J-2416	—
B-2420	—	J-2420	—
B-2620	—	—	—
B-2816	—	J-2816	—
B-2824	—	J-2824	—
B-2816	—	J-2816	—
B-2824	—	J-2824	—

Remarks Inner rings can be used with Y and YH types (pages B76–B79).



FIR

Bore Diameter 5 — 15 mm

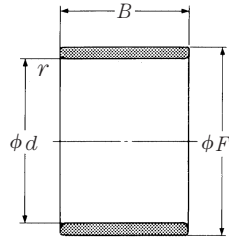


$d$	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx
	$F$	$B$	$r$ min		
5	8	12	0.15	<b>FIR-5812-1</b> <b>FIR-5816-1</b>	0.003
	8	16	0.15		0.004
7	10	12	0.15	<b>FIR-71012-1</b> <b>FIR-71016-1</b>	0.004
	10	16	0.15		0.005
9	12	16	0.3	<b>FIR-91216-1</b>	0.006
10	14	12	0.3	<b>FIR-101412-1</b> <b>FIR-101413-1</b> <b>FIR-101414-1</b>	0.007
	14	13	0.3		0.008
	14	14	0.3		0.008
	14	16	0.3	<b>FIR-101416-1</b> <b>FIR-101420-1</b> <b>FIR-101422-1</b>	0.009
	14	20	0.3		0.012
	14	22	0.3		0.013
12	16	12	0.3	<b>FIR-121612-1</b> <b>FIR-121613-1</b> <b>FIR-121614-1</b>	0.008
	16	13	0.3		0.009
	16	14	0.3		0.010
	16	16	0.3	<b>FIR-121616-1</b> <b>FIR-121620-1</b> <b>FIR-121622-1</b> <b>FIR-121623-1</b>	0.011
	16	20	0.3		0.014
	16	22	0.3		0.015
	16	23	0.3		0.016
	16	23	0.3		0.016
15	20	12	0.3	<b>FIR-152012-1</b> <b>FIR-152013-1</b> <b>FIR-152014-1</b>	0.013
	20	13	0.3		0.014
	20	14	0.3		0.015
	20	18	0.3	<b>FIR-152018-1</b> <b>FIR-152023-1</b> <b>FIR-152024-1</b> <b>FIR-152026-1</b>	0.019
	20	23	0.3		0.025
	20	24	0.3		0.026
	20	26	0.3		0.028
	20	26	0.3		0.028

Matching Solid Needle Roller Bearings			
RLM	RNA	RNAF	RNAFW
RLM81512-1 RLM81516-1			
RLM101712-1 RLM101716-1			
RLM121916-1			
		RNAF142612 RNF142213	
	RNA4900 RNA4900TT		
	RNA5900		RNAFW142220
	RNA6900		
		RNAF162812 RNF162413	
	RNA4901 RNA4901TT		
	RNA5901		
			RNAFW162420
	RNA6901 RNA6901TT		
		RNAF203212 RNF202813	
	RNA4902 RNA4902TT		
	RNA5902 RNA5902 RNA6902TT		
			RNAFW202826

FIR

Bore Diameter 17 — 25 mm

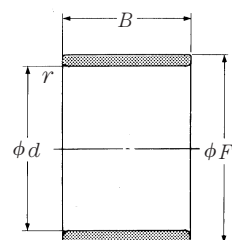


d	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx
	F	B	r min		
17	22	13	0.3	<b>FIR-172213-1</b>	0.016
	22	14	0.3	<b>FIR-172214-1</b>	0.017
	22	16	0.3	<b>FIR-172216-1</b>	0.019
	22	18	0.3	<b>FIR-172218-1</b>	0.022
	22	23	0.3	<b>FIR-172223-1</b>	0.027
	22	24	0.3	<b>FIR-172224-1</b>	0.029
	22	26	0.3	<b>FIR-172226-1</b>	0.031
20	22	32	0.3	<b>FIR-172232-1</b>	0.038
	25	16	0.3	<b>FIR-202516-1</b>	0.022
	25	17	0.3	<b>FIR-202517-1</b>	0.023
	25	18	0.3	<b>FIR-202518-1</b>	0.025
	25	23	0.3	<b>FIR-202523-1</b>	0.032
	25	26	0.3	<b>FIR-202526-1</b>	0.036
	25	30	0.3	<b>FIR-202530-1</b>	0.041
	25	31	0.3	<b>FIR-202531-1</b>	0.043
	25	32	0.3	<b>FIR-202532-1</b>	0.044
	22	28	17	0.3	<b>FIR-222817-1</b>
28		18	0.3	<b>FIR-222818-1</b>	0.033
28		23	0.3	<b>FIR-222823-1</b>	0.042
25	28	30	0.3	<b>FIR-222830-1</b>	0.055
	28	31	0.3	<b>FIR-222831-1</b>	0.057
25	29	20	0.3	<b>FIR-252920-1</b>	0.026
	30	16	0.3	<b>FIR-253016-1</b>	0.027
	30	17	0.3	<b>FIR-253017-1</b>	0.029
	30	18	0.3	<b>FIR-253018-1</b>	0.030
	30	23	0.3	<b>FIR-253023-1</b>	0.039
	30	26	0.3	<b>FIR-253026-1</b>	0.044
	30	30	0.3	<b>FIR-253030-1</b>	0.051
	30	31	0.3	<b>FIR-253031-1</b>	0.052
	30	32	0.3	<b>FIR-253032-1</b>	0.054

RLM	Matching Solid Needle Roller Bearings		
	RNA	RNAF	RNAFW
	RNA4903 RNA4903TT	RNAF223013  RNAF223516	
	RNA5903 RNA6903 RNA6903TT		RNAFW223026 RNAFW223532
	RNA4904 RNA4904TT	RNAF253716 RNAF253517	
	RNA5904		RNAFW253526
	RNA6904		
	RNA6904TT		RNAFW253732
	RNA49/22 RNA49/22TT RNA59/22		
	RNA69/22 RNA69/22TT		
RLM293820-1	RNA4905	RNAF304216 RNAF304017	
	RNA4905TT RNA5905		RNAFW304026
	RNA6905 RNA6905TT		RNAFW304232

FIR

Bore Diameter 28 — 38 mm

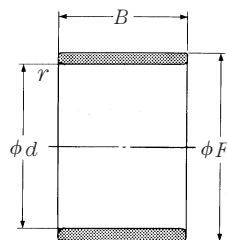


d	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx	
	F	B	r min			
28	32	17	0.3	<b>FIR-283217-1</b>	0.025	
	32	18	0.3	<b>FIR-283218-1</b>	0.026	
	32	23	0.3	<b>FIR-283223-1</b>	0.034	
	32	30	0.3	<b>FIR-283230-1</b>	0.044	
	32	31	0.3	<b>FIR-283231-1</b>	0.046	
	30	35	13	0.3	<b>FIR-303513-1</b>	0.026
35		16	0.3	<b>FIR-303516-1</b>	0.032	
35		17	0.3	<b>FIR-303517-1</b>	0.034	
35		18	0.3	<b>FIR-303518-1</b>	0.036	
35		23	0.3	<b>FIR-303523-1</b>	0.046	
35		26	0.3	<b>FIR-303526-1</b>	0.052	
35		30	0.3	<b>FIR-303530-1</b>	0.060	
35		31	0.3	<b>FIR-303531-1</b>	0.062	
35		32	0.3	<b>FIR-303532-1</b>	0.064	
32		37	30	0.3	<b>FIR-323730-1</b>	0.063
	40	20	0.6	<b>FIR-324020-1</b>	0.071	
	40	21	0.6	<b>FIR-324021-1</b>	0.074	
	40	27	0.6	<b>FIR-324027-1</b>	0.095	
	40	36	0.6	<b>FIR-324036-1</b>	0.127	
	40	37	0.6	<b>FIR-324037-1</b>	0.131	
	35	40	17	0.3	<b>FIR-354017-1</b>	0.039
		40	20	0.3	<b>FIR-354020-1</b>	0.046
40		34	0.3	<b>FIR-354034-1</b>	0.078	
40		40	0.3	<b>FIR-354040-1</b>	0.092	
42		20	0.6	<b>FIR-354220-1</b>	0.066	
42		21	0.6	<b>FIR-354221-1</b>	0.069	
42		27	0.6	<b>FIR-354227-1</b>	0.089	
42		36	0.6	<b>FIR-354236-1</b>	0.119	
42		37	0.6	<b>FIR-354237-1</b>	0.122	
38		43	20	0.3	<b>FIR-384320-1</b>	0.050
	43	30	0.3	<b>FIR-384330-1</b>	0.074	

Matching Solid Needle Roller Bearings			
RLM	RNA	RNAF	RNAFW
	RNA49/28 RNA49/28TT RNA59/28		
	RNA69/28 RNA69/28TT		
		RNAF354513 RNF354716 RNF354517	
	RNA4906		
	RNA4906TT RNA5906		RNAFW354526
	RNA6906 RNA6906TT		RNAFW354732
RLM374730-1	RNA49/32 RNA49/32TT		
	RNA59/32 RNA69/32 RNA69/32TT		
		RNAF405017 RNF405520	RNAFW405034 RNF405540
	RNA4907 RNA4907TT		
	RNA5907 RNA6907 RNA6907TT		
RLM435320-1 RLM435330-1			

FIR

Bore Diameter 40 — 50 mm

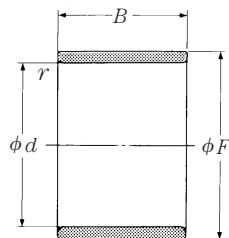


d	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx
	F	B	r min		
40	45	17	0.3	<b>FIR-404517-1</b>	0.044
	45	20	0.3	<b>FIR-404520-1</b>	0.052
	45	34	0.3	<b>FIR-404534-1</b>	0.089
	45	40	0.3	<b>FIR-404540-1</b>	0.104
	48	22	0.6	<b>FIR-404822-1</b>	0.095
	48	23	0.6	<b>FIR-404823-1</b>	0.099
	48	30	0.6	<b>FIR-404830-1</b>	0.129
	48	40	0.6	<b>FIR-404840-1</b>	0.173
	48	41	0.6	<b>FIR-404841-1</b>	0.177
42	47	20	0.3	<b>FIR-424720-1</b>	0.055
	47	30	0.3	<b>FIR-424730-1</b>	0.082
45	50	20	0.3	<b>FIR-455020-1</b>	0.058
	50	25	0.3	<b>FIR-455025-1</b>	0.073
	50	35	0.6	<b>FIR-455035-1</b>	0.102
	50	40	0.3	<b>FIR-455040-1</b>	0.116
	52	22	0.6	<b>FIR-455222-1</b>	0.092
	52	23	0.6	<b>FIR-455223-1</b>	0.096
	52	30	0.6	<b>FIR-455230-1</b>	0.125
	52	40	0.6	<b>FIR-455240-1</b>	0.166
	52	41	0.6	<b>FIR-455241-1</b>	0.171
	55	40	0.6	<b>FIR-455540-1</b>	0.245
50	55	20	0.6	<b>FIR-505520-1</b>	0.064
	55	25	0.5	<b>FIR-505525-1</b>	0.080
	55	35	0.3	<b>FIR-505535-1</b>	0.113
	55	40	0.6	<b>FIR-505540-1</b>	0.129
	58	22	0.6	<b>FIR-505822-1</b>	0.116
	58	23	0.6	<b>FIR-505823-1</b>	0.122
	58	30	0.6	<b>FIR-505830-1</b>	0.159
	58	40	0.6	<b>FIR-505840-1</b>	0.212
	58	41	0.6	<b>FIR-505841-1</b>	0.217
	60	20	1	<b>FIR-506020-1</b>	0.135
	60	40	1	<b>FIR-506040-1</b>	0.270

Matching Solid Needle Roller Bearings			
RLM	RNA	RNAF	RNAFW
		RNAF455517 RNAF456220	RNAFW455534 RNAFW456240
	RNA4908 RNA4908TT		
	RNA5908 RNA6908 RNA6908TT		
RLM475720-1 RLM475730-1			
		RNAF506220	
RLM506225 RLM506235-1			
			RNAFW506240
	RNA4909 RNA4909TT		
	RNA5909 RNA6909 RNA6909TT		
			RNAFW557240
		RNAF556820	
RLM556825-1 RLM556835-1			
			RNAFW556840
	RNA4910 RNA4910TT		
	RNA5910 RNA6910 RNA6910TT		
		RNAF607820	
			RNAFW607840

FIR

Bore Diameter 55 — 70 mm

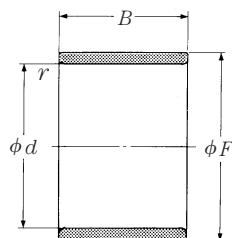


<i>d</i>	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx	
	<i>F</i>	<i>B</i>	<i>r</i> min			
55	60	25	0.3	<b>FIR-556025-1</b>	0.088	
	60	35	0.3	<b>FIR-556035-1</b>	0.123	
	63	25	1	<b>FIR-556325-1</b>	0.145	
	63	26	1	<b>FIR-556326-1</b>	0.150	
	63	34	1	<b>FIR-556334-1</b>	0.197	
	63	45	1	<b>FIR-556345-1</b>	0.260	
	63	46	1	<b>FIR-556346-1</b>	0.266	
	65	30	1	<b>FIR-556530-1</b>	0.221	
	65	60	1	<b>FIR-556560-1</b>	0.441	
	60	68	25	1	<b>FIR-606825-1A</b>	0.157
68		26	1	<b>FIR-606826-1</b>	0.163	
68		34	1	<b>FIR-606834-1</b>	0.213	
68		35	0.6	<b>FIR-606835-1</b>	0.220	
68		45	1	<b>FIR-606845-1</b>	0.282	
68		46	1	<b>FIR-606846-1</b>	0.289	
70		30	1	<b>FIR-607030-1</b>	0.239	
70		60	1	<b>FIR-607060-1</b>	0.478	
65		72	25	1	<b>FIR-657225-1</b>	0.147
		72	26	1	<b>FIR-657226-1</b>	0.153
	72	34	1	<b>FIR-657234-1</b>	0.200	
	72	45	1	<b>FIR-657245-1</b>	0.264	
	72	46	1	<b>FIR-657246-1</b>	0.270	
	73	35	1	<b>FIR-657335-1</b>	0.237	
	75	30	1	<b>FIR-657530-1</b>	0.257	
	75	60	1	<b>FIR-657560-1</b>	0.515	
	70	80	25	1	<b>FIR-708025-1</b>	0.230
		80	30	1	<b>FIR-708030-1</b>	0.276
80		31	1	<b>FIR-708031-1</b>	0.285	
80		35	1	<b>FIR-708035-1</b>	0.322	
80		40	1	<b>FIR-708040-1</b>	0.368	
80		54	1	<b>FIR-708054-1</b>	0.496	
80		55	1	<b>FIR-708055-1</b>	0.505	
80		60	1	<b>FIR-708060-1</b>	0.551	

Matching Solid Needle Roller Bearings			
RLM	RNA	RNAF	RNAFW
RLM607225 RLM607235-1	RNA4911		
	RNA4911TT RNA5911 RNA6911		
	RNA6911TT	RNAF658530	RNAFW658560
RLM688225-1	RNA4912 RNA4912TT RNA5912		
RLM688235-1	RNA6912 RNA6912TT		
		RNAF709030	RNAFW709060
	RNA4913 RNA4913TT RNA5913		
	RNA6913 RNA6913TT		
RLM739035-1		RNAF759530	RNAFW759560
RLM809525-1	RNA4914 RNA4914TT	RNAF8010030	
RLM809535-1	RNA5914 RNA6914		
	RNA6914TT		RNAFW8010060

FIR

Bore Diameter 75 — 100 mm

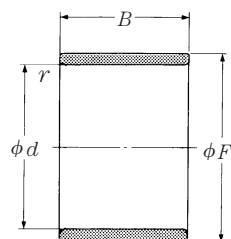


d	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx
	F	B	r min		
75	85	25	1	<b>FIR-758525-1</b>	0.245
	85	30	1	<b>FIR-758530-1</b>	0.294
	85	31	1	<b>FIR-758531-1</b>	0.304
	85	35	1	<b>FIR-758535-1</b>	0.343
	85	40	1	<b>FIR-758540-1</b>	0.392
	85	54	1	<b>FIR-758554-1</b>	0.529
80	85	55	1	<b>FIR-758555-1</b>	0.539
	90	25	1	<b>FIR-809025-1</b>	0.260
	90	30	1	<b>FIR-809030-1</b>	0.312
	90	31	1	<b>FIR-809031-1</b>	0.323
	90	40	1	<b>FIR-809040-1</b>	0.417
	90	54	1	<b>FIR-809054-1</b>	0.562
85	90	55	1	<b>FIR-809055-1</b>	0.573
	95	26	1	<b>FIR-859526-1</b>	0.287
	95	30	1	<b>FIR-859530-1</b>	0.331
	100	35	1.1	<b>FIR-8510035-1</b>	0.595
	100	36	1.1	<b>FIR-8510036-1</b>	0.612
	100	46	1.1	<b>FIR-8510046-1</b>	0.782
90	100	63	1.1	<b>FIR-8510063-1</b>	1.071
	100	64	1.1	<b>FIR-8510064-1</b>	1.088
	100	26	1	<b>FIR-9010026-1</b>	0.303
	100	30	1	<b>FIR-9010030-1</b>	0.349
	105	35	1.1	<b>FIR-9010535-1</b>	0.627
	105	36	1.1	<b>FIR-9010536-1</b>	0.645
95	105	46	1.1	<b>FIR-9010546-1</b>	0.824
	105	63	1.1	<b>FIR-9010563-1</b>	1.129
	110	35	1.1	<b>FIR-9511035-1</b>	0.659
	110	36	1.1	<b>FIR-9511036-1</b>	0.678
	110	46	1.1	<b>FIR-9511046-1</b>	0.867
	110	63	1.1	<b>FIR-9511063-1</b>	1.187
100	110	64	1.1	<b>FIR-9511064-1</b>	1.206
	115	40	1.1	<b>FIR-10011540-1</b>	0.790
	115	41	1.1	<b>FIR-10011541-1</b>	0.810
	115	54	1.1	<b>FIR-10011554-1</b>	1.067

Matching Solid Needle Roller Bearings			
RLM	RNA	RNAF	RNAFW
RLM8510525-1	RNA4915 RNA4915TT	RNAF8510530	
RLM8510535-1	RNA5915 RNA6915 RNA6915TT		
RLM9011025-1	RNA4916 RNA4916TT	RNAF9011030	
	RNA5916 RNA6916 RNA6916TT		
RLM9511526-1		RNAF9511530	
	RNA4917 RNA4917TT RNA5917 RNA6917 RNA6917TT		
RLM10012026-1		RNAF10012030	
	RNA4918 RNA4918TT RNA5918 RNA6918		
	RNA4919 RNA4919TT RNA5919 RNA6919 RNA6919TT		
	RNA4920 RNA4920TT RNA5920		

FIR

Bore Diameter 110 — 220 mm

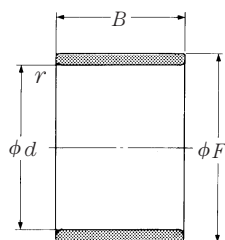


$d$	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (kg) approx
	$F$	$B$	$r$ min		
<b>110</b>	120	30	1	<b>FIR-11012030-1</b>	0.423
	125	40	1.1	<b>FIR-11012540-1</b>	0.864
	125	41	1.1	<b>FIR-11012541-1</b>	0.885
	125	54	1.1	<b>FIR-11012554-1</b>	1.166
<b>120</b>	130	30	1	<b>FIR-12013030-1</b>	0.459
	135	45	1.1	<b>FIR-12013545-1</b>	1.054
	135	60	1.1	<b>FIR-12013560-1</b>	1.406
<b>130</b>	145	35	1.1	<b>FIR-13014535-1</b>	0.884
	150	50	1.5	<b>FIR-13015050-1</b>	1.715
	150	67	1.5	<b>FIR-13015067-1</b>	2.298
<b>140</b>	155	35	1.1	<b>FIR-14015535-1</b>	0.949
	160	50	1.5	<b>FIR-14016050-1</b>	1.838
	160	67	1.5	<b>FIR-14016067-1</b>	2.463
<b>150</b>	165	40	1.1	<b>FIR-15016540-1</b>	1.158
	170	60	2	<b>FIR-15017060-1</b>	2.352
<b>160</b>	175	40	1.1	<b>FIR-16017540-1</b>	1.231
	180	60	2	<b>FIR-16018060-1</b>	2.499
<b>170</b>	185	45	1.1	<b>FIR-17018545-1</b>	1.468
	190	60	2	<b>FIR-17019060-1</b>	2.646
<b>180</b>	195	45	1.1	<b>FIR-18019545-1</b>	1.551
	205	69	2	<b>FIR-18020569-1</b>	4.068
<b>190</b>	210	50	1.5	<b>FIR-19021050-1</b>	2.450
	215	69	2	<b>FIR-19021569-1</b>	4.280
<b>200</b>	220	50	1.5	<b>FIR-20022050-1</b>	2.573
	225	80	2.1	<b>FIR-20022580-1</b>	5.207
<b>220</b>	240	50	1.5	<b>FIR-22024050-1</b>	2.818
	245	80	2.1	<b>FIR-22024580-1</b>	5.697

Matching Solid Needle Roller Bearings			
RLM	RNA	RNAF	RNAFW
	RNA4822		
	RNA4922		
	RNA4922TT		
	RNA5922		
	RNA4824		
	RNA4924		
	RNA5924		
	RNA4826		
	RNA4926		
	RNA5926		
	RNA4828		
	RNA4928		
	RNA5928		
	RNA4830		
	RNA4930		
	RNA4832		
	RNA4932		
	RNA4834		
	RNA4934		
	RNA4836		
	RNA4936		
	RNA4838		
	RNA4938		
	RNA4840		
	RNA4940		
	RNA4844		
	RNA4944		

FIR

Bore Diameter 8 — 20 mm



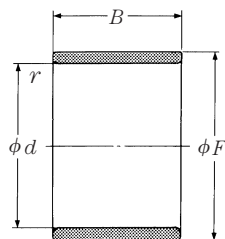
$d$	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (g) approx
	$F$	$B$	$r$ min		
<b>8</b>	12	12.2	0.3	<b>FIR-81212-2</b>	5.9
	12	15.2	0.3	<b>FIR-81215-2</b>	7.4
<b>10</b>	14	16.2	0.3	<b>FIR-101416-2</b>	9.5
	14	20.2	0.3	<b>FIR-101420-2</b>	11.9
	15	8.2	0.3	<b>FIR-10158-2</b>	6.2
	15	12.2	0.3	<b>FIR-101512-2</b>	9.3
	15	15.2	0.3	<b>FIR-101515-2</b>	11.6
<b>12</b>	15	20.2	0.3	<b>FIR-101520-2</b>	15.5
	16	16.2	0.3	<b>FIR-121616-2</b>	11.1
	16	20.2	0.3	<b>FIR-121620-2</b>	13.9
	17	10.2	0.3	<b>FIR-121710-2</b>	9.0
	17	15.2	0.5	<b>FIR-121715-2</b>	13.5
	17	20.2	0.5	<b>FIR-121720-2</b>	17.9
	17	25.2	0.5	<b>FIR-121725-2</b>	22.4
<b>15</b>	18	15.2	0.5	<b>FIR-151815-2</b>	9.2
	18	17.2	0.5	<b>FIR-151817-2</b>	10.4
	18	20.2	0.5	<b>FIR-151820-2</b>	12.3
	18	25.2	0.5	<b>FIR-151825-2</b>	15.3
	19	16.2	0.5	<b>FIR-151916-2</b>	13.5
	19	20.2	0.5	<b>FIR-151920-2</b>	16.8
	20	10.2	0.5	<b>FIR-152010-2</b>	10.9
	20	15.2	0.5	<b>FIR-152015-2</b>	16.3
	20	20.2	0.5	<b>FIR-152020-2</b>	21.7
	20	25.2	0.5	<b>FIR-152025-2</b>	27
<b>17</b>	21	16.2	0.5	<b>FIR-172116-2</b>	15.1
	21	20.2	0.5	<b>FIR-172120-2</b>	18.8
	22	25.2	0.5	<b>FIR-172215-2</b>	18.2
	22	16.2	0.5	<b>FIR-172216-2</b>	19.4
	22	20.2	0.5	<b>FIR-172220-2</b>	24.1
<b>20</b>	22	25.2	0.5	<b>FIR-172225-2</b>	30.1
	24	16.2	0.5	<b>FIR-202416-2</b>	17.5
	24	20.2	0.5	<b>FIR-202420-2</b>	21.8
	24	28.2	0.5	<b>FIR-202428-2</b>	30.4
	25	12.2	0.5	<b>FIR-202512-2</b>	16.8
	25	20.2	0.5	<b>FIR-202520-2</b>	27.8
	25	25.2	0.5	<b>FIR-202525-2</b>	34.7

Matching Solid Needle Roller Bearings	
RLM	
RLM1212	RLM121912 RLM121915
RLM1416 RLM1420 RLM158	
RLM1515 RLM1520	RLM152212 RLM152215 RLM152220
RLM1616 RLM1620 RLM1710	
RLM1720	RLM172415 RLM172425
RLM1815 RLM1817 RLM1820	
RLM1825 RLM1916 RLM1920	
RLM2010 RLM2015 RLM2020 RLM2025	RLM202820
RLM2116 RLM2120 RLM2215	
RLM2220 RLM2225	RLM223016 RLM223020
RLM2420 RLM2428	RLM243216
RLM2512 RLM2520 RLM2525	RLM253320 RLM253325



FIR

Bore Diameter 22 — 50 mm

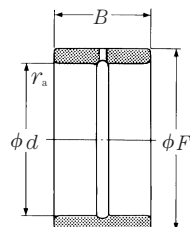


$d$	Boundary Dimensions (mm)			Inner Ring Numbers	Mass (g) approx
	$F$	$B$	$r$ min		
<b>22</b>	26	20.2	0.5	<b>FIR-222620-2</b>	23.8
	28	20.2	0.5	<b>FIR-222820-2</b>	37.1
	28	25.2	0.5	<b>FIR-222825-2</b>	46.3
	28	30.2	0.5	<b>FIR-222830-2</b>	55.5
<b>25</b>	29	20.2	0.5	<b>FIR-252920-2</b>	26.7
	29	30.2	0.5	<b>FIR-252930-2</b>	40
	30	15.2	0.5	<b>FIR-253015-2</b>	25.6
	30	20.2	0.5	<b>FIR-253020-2</b>	34
	30	25.2	0.5	<b>FIR-253025-2</b>	42.5
<b>28</b>	32	20.2	0.5	<b>FIR-283220-2</b>	29.7
	32	30.2	0.5	<b>FIR-283230-2</b>	44.4
<b>30</b>	35	20.2	0.5	<b>FIR-303520-2</b>	40.2
	35	25.2	0.5	<b>FIR-303525-2</b>	50.2
	35	30.2	0.5	<b>FIR-303530-2</b>	60.1
<b>32</b>	37	20.3	0.6	<b>FIR-323720-2</b>	42.9
	37	30.3	0.6	<b>FIR-323730-2</b>	64
	38	15.3	0.6	<b>FIR-323815-2</b>	39.4
	38	20.3	0.6	<b>FIR-323820-2</b>	52.2
	38	25.3	0.6	<b>FIR-323825-2</b>	65.1
	38	30.3	0.6	<b>FIR-323830-2</b>	78
<b>35</b>	40	15.3	0.6	<b>FIR-354015-2</b>	35.1
	40	20.3	0.6	<b>FIR-354020-2</b>	46.6
	40	25.3	0.6	<b>FIR-354025-2</b>	58.1
	40	30.3	0.6	<b>FIR-354030-2</b>	69.6
<b>40</b>	45	20.3	0.6	<b>FIR-404520-2</b>	52.9
	45	25.3	0.6	<b>FIR-404525-2</b>	65.9
	45	30.3	0.6	<b>FIR-404530-2</b>	78.9
<b>42</b>	50	20.3	0.6	<b>FIR-425020-2</b>	91.5
	50	25.3	0.6	<b>FIR-425025-2</b>	114
	50	30.3	0.6	<b>FIR-425030-2</b>	137
<b>45</b>	55	30.3	0.6	<b>FIR-455530-2</b>	186
	55	40.3	0.6	<b>FIR-455540-2</b>	247
<b>50</b>	60	30.3	0.6	<b>FIR-506030-2</b>	204
	60	40.3	0.6	<b>FIR-506040-2</b>	272

Matching Solid Needle Roller Bearings	
RLM	
RLM2620	
RLM2820	RLM283720
RLM2825	
	RLM283730
RLM2920	
RLM2930	
RLM3015	
RLM3020	RLM304020
RLM3025	RLM304025
RLM3220	
RLM3230	
RLM3520	RLM354520
	RLM354525
RLM3530	RLM354530
RLM3720	
RLM3730	
RLM3815	
RLM3820	
RLM3825	
RLM3830	
RLM4015	
RLM4020	
RLM4025	
RLM4030	
RLM4520	
RLM4525	
RLM4530	
RLM5020	RLM506220
	RLM506225
RLM5030	RLM506230
RLM5530	
RLM5540	
	RLM607230
RLM6040	RLM607240

IR

Bore Diameter 9.525 — 39.688 mm

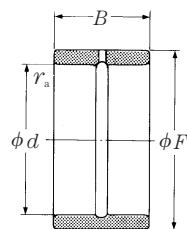


<i>d</i>	Boundary Dimensions (mm, inch)			Inner Ring Numbers
	<i>F</i>	<i>B</i>		
<b>9.525</b>	0.3750	15.875	0.6250	<b>IR-061012</b>
<b>12.700</b>	0.5000	19.050	0.7500	<b>IR-081212</b>
		19.050	0.7500	<b>IR-081216</b>
<b>15.875</b>	0.6250	22.225	0.8750	<b>IR-101412</b>
		22.225	0.8750	<b>IR-101416</b>
<b>17.462</b>	0.6875	22.225	0.8750	<b>IR-111412</b>
<b>19.050</b>	0.7500	25.400	1.0000	<b>IR-121612</b>
		25.400	1.0000	<b>IR-121616</b>
<b>20.638</b>	0.8125	25.400	1.0000	<b>IR-131616</b>
<b>22.225</b>	0.8750	28.575	1.1250	<b>IR-141816</b>
		28.575	1.1250	<b>IR-141820</b>
<b>23.812</b>	0.9375	28.575	1.1250	<b>IR-151816</b>
		28.575	1.1250	<b>IR-151820</b>
<b>25.400</b>	1.0000	31.750	1.2500	<b>IR-162016</b>
		31.750	1.2500	<b>IR-162020</b>
<b>28.575</b>	1.1250	34.925	1.3750	<b>IR-182216</b>
		34.925	1.3750	<b>IR-182220</b>
<b>30.162</b>	1.1875	38.100	1.5000	<b>IR-192420</b>
<b>31.750</b>	1.2500	38.100	1.5000	<b>IR-202416</b>
		38.100	1.5000	<b>IR-202420</b>
<b>33.338</b>	1.3125	41.275	1.6250	<b>IR-212616</b>
		41.275	1.6250	<b>IR-212620</b>
<b>34.925</b>	1.3750	41.275	1.6250	<b>IR-222620</b>
		44.450	1.7500	<b>IR-222820</b>
<b>36.512</b>	1.4375	44.450	1.7500	<b>IR-232816</b>
		44.450	1.7500	<b>IR-232820</b>
<b>38.100</b>	1.5000	44.450	1.7500	<b>IR-242816</b>
		44.450	1.7500	<b>IR-242820</b>
<b>39.688</b>	1.5625	50.800	2.0000	<b>IR-243220</b>
<b>39.688</b>	1.5625	47.625	1.8750	<b>IR-253020</b>
		50.800	2.0000	<b>IR-253220</b>

Mass (kg)	Fillet Radius of Shaft (mm)	Matching Solid Needle Roller Bearings
approx	<i>r<sub>a</sub></i> max	HJ
0.018	0.6	HJ-101812
0.027	1	HJ-122012
0.037	1	HJ-122016
0.026	1	HJ-142212
0.033	1	HJ-142216
0.023	1	HJ-142212
0.032	1	HJ-162412
0.044	1	HJ-162416
0.034	1	HJ-162416
0.050	1	HJ-182616
0.065	1	HJ-182620
0.040	1	HJ-182616
0.050	1	HJ-182620
0.060	1	HJ-202816
0.075	1	HJ-202820
0.065	1	HJ-223016
0.075	1	HJ-223020
0.105	1.5	HJ-243320
0.075	1.5	HJ-243316
0.090	1.5	HJ-243320
0.095	1.5	HJ-263516
0.12	1.5	HJ-263520
0.10	1.5	HJ-263520
0.145	1.5	HJ-283720
0.10	1.5	HJ-283716
0.125	1.5	HJ-283720
0.095	1.5	HJ-283716
0.10	1.5	HJ-283720
0.22	1.5	HJ-324120
0.135	1.5	HJ-303920
0.195	1.5	HJ-324120

IR

Bore Diameter 41.275 — 107.950 mm

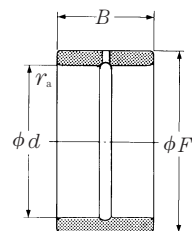


<i>d</i>	Boundary Dimensions (mm, inch)			Inner Ring Numbers
	<i>F</i>	<i>B</i>		
<b>41.275</b>	1.6250	50.800	2.0000	<b>IR-263220</b>
<b>42.862</b>	1.6875	50.800	2.0000	<b>IR-273216</b>
		50.800	2.0000	<b>IR-273220</b>
		50.800	2.0000	
<b>44.450</b>	1.7500	57.150	2.2500	<b>IR-283624</b>
		57.150	2.2500	<b>IR-283628</b>
<b>49.212</b>	1.9375	63.500	2.5000	<b>IR-314024</b>
		63.500	2.5000	<b>IR-314028</b>
<b>50.800</b>	2.0000	63.500	2.5000	<b>IR-324024</b>
		63.500	2.5000	<b>IR-324028</b>
<b>55.562</b>	2.1875	69.850	2.7500	<b>IR-354428</b>
		69.850	2.7500	
<b>57.150</b>	2.2500	69.850	2.7500	<b>IR-364424</b>
		69.850	2.7500	<b>IR-364428</b>
<b>60.325</b>	2.3750	76.200	3.0000	<b>IR-384828</b>
		76.200	3.0000	
<b>63.500</b>	2.5000	76.200	3.0000	<b>IR-404824</b>
		76.200	3.0000	<b>IR-404828</b>
<b>69.850</b>	2.7500	82.550	3.2500	<b>IR-445228</b>
		82.550	3.2500	<b>IR-445232</b>
<b>74.612</b>	2.9375	88.900	3.5000	<b>IR-475632</b>
		88.900	3.5000	<b>IR-485632</b>
<b>76.200</b>	3.0000	88.900	3.5000	<b>IR-485632</b>
		88.900	3.5000	<b>IR-506032</b>
<b>79.375</b>	3.1250	95.250	3.7500	<b>IR-506032</b>
		95.250	3.7500	
<b>82.550</b>	3.2500	95.250	3.7500	<b>IR-526032</b>
		101.600	4.0000	<b>IR-526432</b>
<b>85.725</b>	3.3750	101.600	4.0000	<b>IR-546432</b>
		101.600	4.0000	
<b>88.900</b>	3.5000	101.600	4.0000	<b>IR-566432</b>
		107.950	4.2500	<b>IR-566832</b>
<b>95.250</b>	3.7500	107.950	4.2500	<b>IR-606832</b>
		114.300	4.5000	<b>IR-607236</b>
<b>101.600</b>	4.0000	114.300	4.5000	<b>IR-607240</b>
		114.300	4.5000	
<b>101.600</b>	4.0000	127.000	5.0000	<b>IR-648036</b>
		127.000	5.0000	<b>IR-648040</b>
<b>107.950</b>	4.2500	127.000	5.0000	<b>IR-688036</b>

Mass (kg)	Fillet Radius of Shaft (mm)	Matching Solid Needle Roller Bearings
approx	$r_a$ max	HJ
0.17	1.5	HJ-324120
0.12	1.5	HJ-324116
0.145	1.5	HJ-324120
0.305	1.5	HJ-364824
0.355	1.5	HJ-364828
0.375	2	HJ-405224
0.425	2	HJ-405228
0.34	2	HJ-405224
0.40	2	HJ-405228
0.50	2	HJ-445628
0.375	2	HJ-445624
0.45	2	HJ-445628
0.57	2	HJ-486028
0.44	2	HJ-486024
0.47	2	HJ-486028
0.50	2	HJ-526828
0.60	2	HJ-526832
0.75	2	HJ-567232
0.70	2	HJ-567232
0.90	2.5	HJ-607632
0.70	2.5	HJ-607632
1.1	2.5	HJ-648032
0.90	2.5	HJ-648032
0.75	2.5	HJ-648032
1.15	2.5	HJ-688432
1.0	2.5	HJ-688432
1.4	2.5	HJ-729636
1.55	2.5	HJ-729640
2.05	2.5	HJ-8010436
2.25	2.5	HJ-8010440
1.55	2.5	HJ-8010436

IR

Bore Diameter 114.300 — 203.200 mm



<i>d</i>	Boundary Dimensions (mm, inch)			Inner Ring Numbers
	<i>F</i>	<i>B</i>	<i>F</i>	
<b>114.300</b>	4.5000	139.700	5.5000	<b>IR-728840</b> <b>IR-728848</b>
		139.700	5.5000	
<b>120.650</b>	4.7500	146.050	5.7500	<b>IR-769248</b> <b>IR-809640</b>
	<b>127.000</b>	5.0000	152.400	
<b>139.700</b>	5.5000	165.100	6.5000	<b>IR-8810440</b> <b>IR-8810448</b>
		165.100	6.5000	
<b>152.400</b>	6.0000	184.150	7.2500	<b>IR-9611648</b> <b>IR-10412448</b> <b>IR-11213248</b>
	<b>165.100</b>	6.5000	196.850	
	<b>177.800</b>	7.0000	209.550	
<b>190.500</b>	7.5000	222.250	8.7500	<b>IR-12014048</b> <b>IR-12814848</b>
	<b>203.200</b>	8.0000	234.950	

Mass (kg)	Fillet Radius of Shaft (mm)	Matching Solid Needle Roller Bearings
approx	$r_a$ max	HJ
2.5	2.5	HJ-8811240
2.95	2.5	HJ-8811248
3.15	3	HJ-9211648
2.75	3	HJ-9612040
3.35	3	HJ-9612048
3.05	3	HJ-10412840
3.65	3	HJ-10412848
4.9	3	HJ-11614648
5.5	3	HJ-12415448
5.55	3	HJ-13216248
6.15	4	HJ-14017048
6.4	4	HJ-14817848

## THRUST BEARINGS

### CAGE & NEEDLE ROLLER ASSEMBLIES FOR THRUST NEEDLE BEARINGS

			Pages
Metric Design	Bore Diameter	10–100 mm .....	B168–B169
Inch Design	Bore Diameter	6.350–104.775 mm .....	B170–B171

### THRUST NEEDLE BEARINGS WITH INTEGRATED RACEWAY WASHERS

Metric Design (FB)	Bore Diameter	20–55 mm .....	B172–B173
Metric Design (FH, FG)	Bore Diameter	22.6–43 mm .....	B174–B175

Thrust needle bearings type comes in metric and inch designs.

The cage & Needle roller assembly for the thrust needle bearing is a cage that has two pieces joined together (refer to **Fig. 1**), to which surface hardening is applied after the precision press processing of a steel plate, and in which high accuracy rollers are incorporated, in order to achieve rigidity and wear resistance. Many rollers are retained securely in the cage, taking large axial load, and yet rotating smoothly. Mounting space is so small that it is easy to replace a conventional sliding thrust washer. Different thicknesses of various types of thrust raceway washers are available in this cage & Needle roller assembly, which allows selection of the appropriate thickness suited for bearing peripheral mounting conditions.

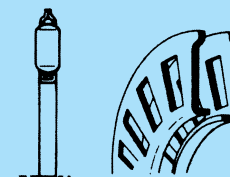


Fig. 1



**Type**

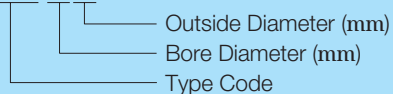
Several types of thrust bearings are shown in **Table 1**.  
 For inch bearings, the dimension number is expressed in integers in units of 1/16 inch.  
 Raceway washers are available for use when the raceway surface cannot be hardened by heat treatment and ground to the proper finish.  
 Types of raceway washers used for cage & Needle roller assemblies in thrust needle bearings are shown in **Table 2**.

**Table 1 Bearing Types**

Code		Description
Metric	FNTA	Cage & Needle roller assemblies for thrust needle bearings
	FB, FG, FH	Thrust needle bearings with integrated raceway washers
Inch	NTA, NTC	Cage & Needle roller assemblies for thrust needle bearings

The composition of bearing numbers is as follows:

**(Example) FNTA-2035**



**Table 2 Raceway Washers of Thrust Needle Bearings**

Units: mm

Metric		Inch	
Type	Thickness	Type	Thickness
FTRA	1.0	TRA	0.8
FTRB	1.5	TRB	1.6
FTRC	2.0	TRC	2.4
FTRD	2.5	TRD	3.2
FTRE	3.0	TRE	4.0
—	—	TRF	4.8

Other than the rings shown in **Table 2**, raceway washers with flanges at the bore or outside are also available.

**Accuracy**

**Thrust Needle Bearings**

NSK metric FNTA cage & Needle roller assemblies conform with ISO criteria, and the fitting tolerance of the cage born diameter is E11 and that of the outside diameter is c12.

The dimensional tolerances for inch NTA cage & Needle roller assemblies, and metric and inch thrust raceway washers are shown in the dimensional table. The accuracy class of the rollers is Class 3 of ISO.

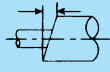
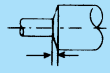
**Application**

**Thrust Needle Bearings**

When using FNTA and NTA cage & Needle roller assemblies, using the gear side as a raceway ring saves bearing space (refer to **Fig. 2**).

In general, the accuracy, surface roughness, and hardness of the raceway components should satisfy the specifications shown in **Table 3**.

**Table 3 Specifications of Thrust Bearing Raceway Surface**

Squareness A	0.5/1000 (mm/mm)	
Squareness B	1.0/1000 (mm/mm)	
Roughness, (1) Ra	0.4	—
Hardness, (2)	HRC 58 to 64 (HRC60 to 64 is favorable)	—

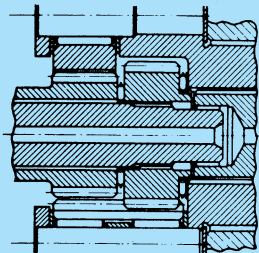
**Notes** (1) Refer to Section 5.2 on page A34 for details.  
 (2) Refer to Section 5.3 on page A35 for details.

When a cage & Needle roller assembly cannot be used by itself, a thrust raceway washer should be employed. The raceway washer should be selected after considering washer support face and the volume of the load. The thrust raceway washer should be set to prevent sliding between the contact surfaces.

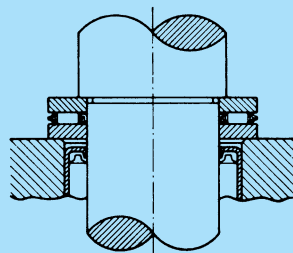
When the area supporting the raceway washer is sufficiently large, a thin raceway washer, such as the FTRA and TRA types, can be used. It should be noted that even if the washers of the FTRA and TRA types are warped, an axial load of more than approximately 196 N {20 kgf} will flatten them.

When the support face of the shaft or housing is small (refer to **Fig. 3**), FTRE and TRD types, which are thick-wall raceway washers, or any of the other thicker types should be used. In any case, to bring out the full performance of the bearing, the squareness of the support face should be ensured and sufficient space is needed in the support face.

For squareness of the raceway washer support face, the values shown in **Table 3** are applied. Please consult NSK regarding shape and accuracy.



**Fig. 2**



**Fig. 3**

**Bearing Guide**

The cages used in FNTA and NTA cage & Needle roller assemblies are guided by the shaft along their extended cage bore.

Bore diameter tolerance is smaller than that for the outside diameter, and as relative speed at the guide face is slow, the bore guiding method is effective. When the outside of the cage is guided, it is necessary for the housing guide surface to be hardened, at least on its surface, to protect it from wear.

**Fitting**

Recommended fittings for thrust needle bearings is shown in **Table 4**.

**Table 4 Recommended Fitting for Thrust Bearing**

Units: mm

Classification	Type	Cage or Raceway Washer Guide	Fitting Class or Tolerance	
			Shaft	Housing Bore
Thrust Needle Bearing Cage & Needle Roller Assembly	FNTA	Bore	h8	$D_c + \text{over } 1.0$
		Outside	—	H10
	NTA NTC	Bore	$\begin{matrix} 0 \\ -0.075 \end{matrix}$	$D_c + \text{over } 1.0$
		Outside	—	H10
Thrust Needle Bearing Raceway Washer	FTRA — FTRE	Bore	h8	$D_c + \text{over } 1.0$
		Outside	—	H10
	TRA — TRF	Bore	$\begin{matrix} 0 \\ -0.075 \end{matrix}$	$D_c + \text{over } 1.0$
		Outside	—	H10

**Remarks**  $D_c$  in the table to the bore and outside surface of the cage.  
 Please consult NSK regarding fitting of bearing types other than those shown in **Table 4**.

Thrust Needle Bearings

FNTA (Thrust Cage & Needle Roller Assemblies)

FTRA (Thrust Bearing Rings  $s = 1.0$ )

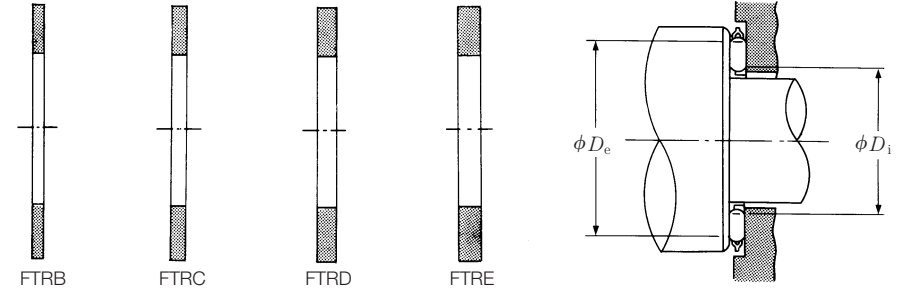
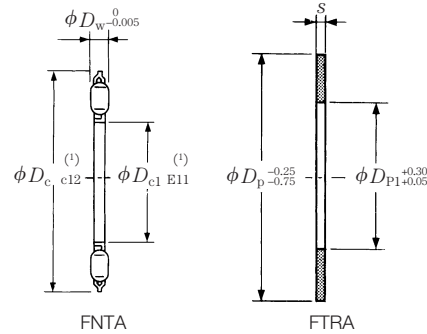
FTRB ( $s = 1.5$ )

FTRC ( $s = 2.0$ )

FTRD ( $s = 2.5$ )

FTRE ( $s = 3.0$ )

Bore Diameter 10 — 100 mm



Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers
$D_{Ci}, D_{Pi}$	$D_{C}, D_{P}$	$D_w$	$C_a$	$C_{oa}$	$C_a$	$C_{oa}$		
							Oil	
10	24	2	7 750	23 000	790	2 350	17 000	FNTA-1024
12	26	2	8 350	26 300	855	2 680	16 000	FNTA-1226
13	26	2	8 050	25 400	825	2 590	16 000	FNTA-1326
15	28	2	7 950	25 800	810	2 630	15 000	FNTA-1528
16	29	2	8 200	27 100	835	2 770	14 000	FNTA-1629
17	30	2	8 400	28 400	855	2 900	14 000	FNTA-1730
18	31	2	8 600	29 700	875	3 050	13 000	FNTA-1831
20	35	2	11 900	47 000	1 220	4 800	12 000	FNTA-2035
25	42	2	14 800	66 000	1 510	6 750	9 500	FNTA-2542
30	47	2	16 500	79 000	1 680	8 100	8 500	FNTA-3047
35	52	2	17 300	88 000	1 770	8 950	8 000	FNTA-3552
40	60	3	26 900	122 000	2 740	12 400	6 700	FNTA-4060
45	65	3	28 700	137 000	2 930	14 000	6 300	FNTA-4565
50	70	3	30 500	152 000	3 100	15 500	5 600	FNTA-5070
55	78	3	37 000	201 000	3 750	20 500	5 300	FNTA-5578
60	85	3	43 000	252 000	4 400	25 700	4 800	FNTA-6085
65	90	3	45 500	274 000	4 600	28 000	4 500	FNTA-6590
70	95	4	59 000	320 000	6 000	33 000	4 300	FNTA-7095
75	100	4	60 000	335 000	6 150	34 500	4 000	FNTA-75100
80	105	4	63 000	365 000	6 450	37 500	3 800	FNTA-80105
85	110	4	64 500	380 000	6 550	39 000	3 600	FNTA-85110
90	120	4	80 000	515 000	8 150	52 500	3 400	FNTA-90120
100	135	4	98 500	695 000	10 000	71 000	3 000	FNTA-100135

Note (1) For tolerance classes c12 and E11, please refer to pages C58 and C60, respectively.

Matching Bearing Rings					Roller Contact Surfaces (mm)		Mass approx (g)	
$s = 1.0 \pm 0.05$	$s = 1.5 \pm 0.05$	$s = 2.0 \pm 0.05$	$s = 2.5 \pm 0.05$	$s = 3.0 \pm 0.05$	$D_e$ min	$D_i$ max	FNTA	FTRA
* FTRA-1024	FTRB-1024	FTRC-1024	—	—	22	11.5	2.3	2.9
FTRA-1226	FTRB-1226	FTRC-1226	—	—	24	13.5	3.4	3.3
FTRA-1326	FTRB-1326	FTRC-1326	—	—	24	14.5	3.3	3.1
FTRA-1528	FTRB-1528	FTRC-1528	FTRD-1528	FTRE-1528	26	16.5	3.5	3.5
FTRA-1629	FTRB-1629	FTRC-1629	FTRD-1629	FTRE-1629	27	17.5	3.7	3.6
FTRA-1730	FTRB-1730	FTRC-1730	FTRD-1730	FTRE-1730	28	18.5	3.8	3.8
FTRA-1831	FTRB-1831	FTRC-1831	FTRD-1831	FTRE-1831	29	19.5	4.0	3.9
FTRA-2035	FTRB-2035	FTRC-2035	FTRD-2035	FTRE-2035	33	21.5	5.4	5.1
FTRA-2542	FTRB-2542	FTRC-2542	FTRD-2542	FTRE-2542	40	26.5	7.7	7.0
FTRA-3047	FTRB-3047	FTRC-3047	FTRD-3047	FTRE-3047	45	31.5	8.9	7.9
FTRA-3552	FTRB-3552	FTRC-3552	FTRD-3552	FTRE-3552	50.5	36.5	9.7	9.1
FTRA-4060	FTRB-4060	FTRC-4060	FTRD-4060	FTRE-4060	57	42	18	12
FTRA-4565	FTRB-4565	FTRC-4565	FTRD-4565	FTRE-4565	62	47	20	13
FTRA-5070	FTRB-5070	FTRC-5070	FTRD-5070	FTRE-5070	67	51.5	22	15
FTRA-5578	FTRB-5578	FTRC-5578	FTRD-5578	FTRE-5578	75	57	29	19
FTRA-6085	FTRB-6085	FTRC-6085	FTRD-6085	FTRE-6085	82	61.5	35	22
FTRA-6590	FTRB-6590	FTRC-6590	FTRD-6590	FTRE-6590	87.5	66.5	38	24
FTRA-7095	FTRB-7095	FTRC-7095	FTRD-7095	FTRE-7095	92.5	71.5	52	25
FTRA-75100	FTRB-75100	FTRC-75100	FTRD-75100	FTRE-75100	97.5	76.5	54	27
FTRA-80105	FTRB-80105	FTRC-80105	FTRD-80105	FTRE-80105	102.5	81.5	58	28
FTRA-85110	FTRB-85110	FTRC-85110	FTRD-85110	FTRE-85110	107.5	86.5	63	30
FTRA-90120	FTRB-90120	FTRC-90120	FTRD-90120	FTRE-90120	117.5	91.5	80	38
FTRA-100135	FTRB-100135	FTRC-100135	FTRD-100135	FTRE-100135	132.5	101.5	105	50

\* The tolerance of this bearing's bore diameter is +0.025 to +0.175 mm and its outside diameter tolerance is -0.040 to -0.370 mm.



Thrust Needle Bearings

NTA (Thrust Cage & Needle Roller Assemblies)

NTC

TRA (Thrust Bearing Rings  $s = 0.8$ )

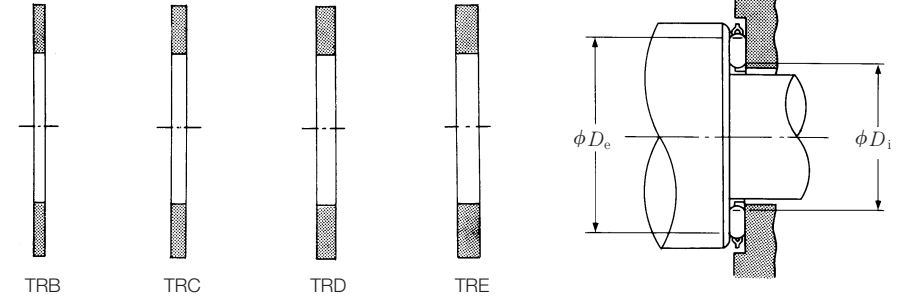
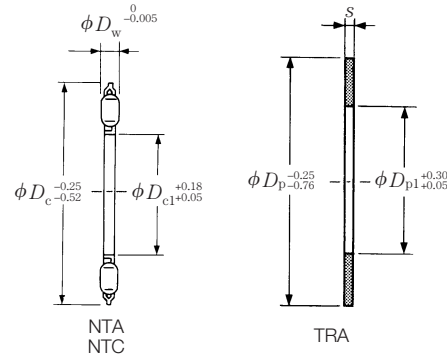
TRB ( $s = 1.6$ )

TRC ( $s = 2.4$ )

TRD ( $s = 3.2$ )

TRE ( $s = 4.0$ )

Bore Diameter 6.350 — 104.775 mm



$D_{c1}, D_{p1}$	Boundary Dimensions (mm, inch)			Basic Load Ratings (N)				Limiting Speeds ( $\text{min}^{-1}$ ) Oil		
	$D_c, D_p$	$D_w$		$C_a$	$C_{oa}$	$C_a$	$C_{oa}$			
<b>6.350</b>	0.2500	17.450	—	1.984	—	4 400	9 900	450	1 010	24 000
<b>7.925</b>	—	19.050	0.7500	1.984	—	4 950	12 100	505	1 230	22 000
<b>9.525</b>	0.3750	20.625	—	1.984	—	5 200	13 200	530	1 350	20 000
<b>12.700</b>	0.5000	23.800	—	1.984	—	6 150	17 600	625	1 790	18 000
<b>14.275</b>	—	25.400	1.0000	1.984	—	6 600	19 800	670	2 020	17 000
<b>15.875</b>	0.6250	28.575	1.1250	1.984	—	8 100	26 600	825	2 720	15 000
<b>19.050</b>	0.7500	31.750	1.2500	1.984	—	9 000	32 000	915	3 250	13 000
<b>22.225</b>	0.8750	36.500	—	1.984	—	11 600	46 500	1 180	4 750	11 000
		42.850	—	1.984	—	16 300	74 500	1 660	7 600	9 500
<b>25.400</b>	1.0000	39.675	—	1.984	—	12 000	50 000	1 220	5 100	10 000
<b>28.575</b>	1.1250	44.450	1.7500	1.984	—	14 800	68 000	1 510	6 950	9 000
<b>31.750</b>	1.2500	49.200	—	1.984	—	17 700	88 500	1 800	9 050	8 000
<b>34.925</b>	1.3750	52.375	—	1.984	—	18 700	98 000	1 910	10 000	7 500
<b>38.100</b>	1.5000	55.550	—	1.984	—	20 400	112 000	2 080	11 400	7 500
<b>44.450</b>	1.7500	63.500	2.5000	1.984	—	20 400	117 000	2 080	11 900	6 700
<b>50.800</b>	2.0000	69.850	2.7500	1.984	—	21 100	126 000	2 150	12 800	6 000
<b>53.975</b>	2.1250	73.025	2.8750	1.984	—	21 400	131 000	2 190	13 300	5 600
<b>57.150</b>	2.2500	76.200	3.0000	1.984	—	21 800	135 000	2 220	13 800	5 300
		79.375	3.1250	3.175	0.1250	33 500	172 000	3 450	17 500	5 000
<b>63.500</b>	2.5000	82.550	3.2500	1.984	—	22 400	145 000	2 290	14 700	5 000
<b>69.850</b>	2.7500	92.075	3.6250	3.175	0.1250	42 500	248 000	4 350	25 300	4 500
<b>76.200</b>	3.0000	95.250	3.7500	1.984	—	23 700	163 000	2 410	16 600	4 300
<b>82.550</b>	3.2500	104.775	4.1250	3.175	0.1250	46 000	287 000	4 700	29 200	3 800
<b>95.250</b>	3.7500	117.475	4.6250	3.175	0.1250	50 000	335 000	5 100	34 000	3 400
<b>104.775</b>	4.1250	128.575	—	3.175	0.1250	57 000	405 000	5 800	41 000	3 200

Bearing Numbers	Matching Bearing Rings						Roller Contact Surfaces (mm)		Mass (g)	
	$s=0.8$ <sup>+0.01</sup> / <sub>-0.04</sub>	$s=1.6$ <sup>0</sup> / <sub>-0.08</sub>	$s=2.4$ <sup>+0.01</sup> / <sub>-0.07</sub>	$s=3.2$ <sup>0</sup> / <sub>-0.08</sub>	$s=4.0$ <sup>-0.01</sup> / <sub>-0.09</sub>	$D_e$ min	$D_i$ max	approx NTA	TRA	
<b>NTA-411</b>	<b>TRA-411</b>	<b>TRB-411</b>	<b>TRC-411</b>	—	—	16	7.5	1.4	1.4	
<b>NTA-512</b>	<b>TRA-512</b>	<b>TRB-512</b>	—	—	—	17.5	9	1.8	1.4	
<b>NTA-613</b>	<b>TRA-613</b>	<b>TRB-613</b>	<b>TRC-613</b>	—	—	19	10.5	1.8	1.4	
<b>NTA-815</b>	<b>TRA-815</b>	<b>TRB-815</b>	<b>TRC-815</b>	—	—	22	14	2.3	1.8	
<b>NTA-916</b>	<b>TRA-916</b>	<b>TRB-916</b>	<b>TRC-916</b>	—	—	23.5	15.5	2.7	2.3	
<b>NTA-1018</b>	<b>TRA-1018</b>	<b>TRB-1018</b>	<b>TRC-1018</b>	<b>TRD-1018</b>	<b>TRE-1018</b>	27	17	3.2	2.7	
<b>NTA-1220</b>	<b>TRA-1220</b>	<b>TRB-1220</b>	<b>TRC-1220</b>	<b>TRD-1220</b>	<b>TRE-1220</b>	30	20	4.1	3.2	
<b>NTA-1423</b>	<b>TRA-1423</b>	<b>TRB-1423</b>	<b>TRC-1423</b>	<b>TRD-1423</b>	—	34.5	23.5	5.0	4.1	
<b>NTC-1427</b>	—	<b>TRB-1427</b>	<b>TRC-1427</b>	<b>TRD-1427</b>	—	41	25	9.1	—	
<b>NTA-1625</b>	<b>TRA-1625</b>	<b>TRB-1625</b>	<b>TRC-1625</b>	<b>TRD-1625</b>	<b>TRE-1625</b>	38	26.5	5.9	4.5	
<b>NTA-1828</b>	<b>TRA-1828</b>	<b>TRB-1828</b>	<b>TRC-1828</b>	<b>TRD-1828</b>	—	42.5	29.5	8.6	5.9	
<b>NTA-2031</b>	<b>TRA-2031</b>	<b>TRB-2031</b>	<b>TRC-2031</b>	<b>TRD-2031</b>	—	47.5	33	9.5	6.8	
<b>NTA-2233</b>	<b>TRA-2233</b>	<b>TRB-2233</b>	<b>TRC-2233</b>	<b>TRD-2233</b>	<b>TRE-2233</b>	50.5	36	10	7.3	
<b>NTA-2435</b>	<b>TRA-2435</b>	<b>TRB-2435</b>	<b>TRC-2435</b>	<b>TRD-2435</b>	—	53.5	39	11	7.7	
<b>NTA-2840</b>	<b>TRA-2840</b>	<b>TRB-2840</b>	<b>TRC-2840</b>	<b>TRD-2840</b>	—	60	45.5	14	9.5	
<b>NTA-3244</b>	<b>TRA-3244</b>	<b>TRB-3244</b>	<b>TRC-3244</b>	<b>TRD-3244</b>	—	66.5	52	15	11	
<b>NTA-3446</b>	<b>TRA-3446</b>	<b>TRB-3446</b>	<b>TRC-3446</b>	<b>TRD-3446</b>	—	69.5	55	16	12	
<b>NTA-3648</b>	<b>TRA-3648</b>	<b>TRB-3648</b>	<b>TRC-3648</b>	<b>TRD-3648</b>	—	72.5	58.5	17	12	
<b>NTA-3650</b> <sup>(1)</sup>	—	—	—	—	—	76.5	58.5	29	—	
<b>NTA-4052</b>	<b>TRA-4052</b> <sup>(2)</sup>	<b>TRB-4052</b> <sup>(2)</sup>	<b>TRC-4052</b> <sup>(2)</sup>	<b>TRD-4052</b> <sup>(2)</sup>	—	79	64.5	19	14	
<b>NTA-4458</b> <sup>(1)</sup>	<b>TRA-4458</b> <sup>(2)</sup>	<b>TRB-4458</b> <sup>(2)</sup>	<b>TRC-4458</b> <sup>(2)</sup>	<b>TRD-4458</b> <sup>(2)</sup>	—	89	71.5	37	18	
<b>NTA-4860</b>	<b>TRA-4860</b> <sup>(2)</sup>	<b>TRB-4860</b> <sup>(2)</sup>	—	<b>TRD-4860</b> <sup>(2)</sup>	—	92	77.5	22	16	
<b>NTA-5266</b> <sup>(1)</sup>	<b>TRA-5266</b> <sup>(2)</sup>	—	—	<b>TRD-5266</b> <sup>(2)</sup>	—	102	84	42	20	
<b>NTA-6074</b> <sup>(1)</sup>	<b>TRA-6074</b> <sup>(2)</sup>	<b>TRB-6074</b> <sup>(2)</sup>	<b>TRC-6074</b> <sup>(2)</sup>	<b>TRD-6074</b> <sup>(2)</sup>	—	114.5	97	50	23	
<b>NTA-6681</b> <sup>(1)</sup>	<b>TRA-6681</b> <sup>(2)</sup>	—	<b>TRC-6681</b> <sup>(2)</sup>	<b>TRD-6681</b> <sup>(2)</sup>	—	125.5	106.5	62	27	

Notes <sup>(1)</sup> Tolerance of cage bore diameter is +0.05 to +0.25mm, and tolerance of cage outside diameter is -0.25 to -0.64mm.

<sup>(2)</sup> Tolerance of bearing ring bore diameter is +0.05 to -0.43mm.

Thrust Needle Bearings

FB (With Integrated Raceway Washers)

FTRA (Thrust Bearing Rings  $s = 1.0$ )

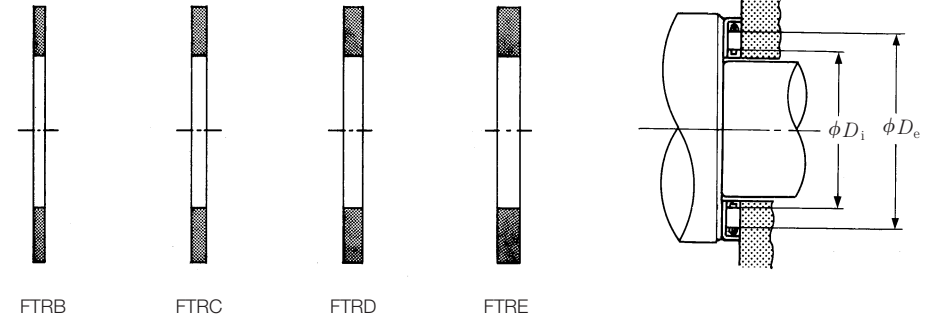
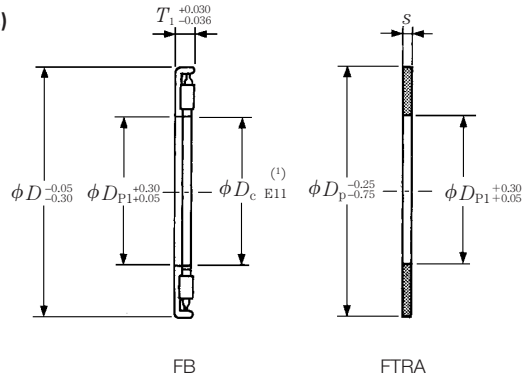
FTRB ( $s = 1.5$ )

FTRC ( $s = 2.0$ )

FTRD ( $s = 2.5$ )

FTRE ( $s = 3.0$ )

Bore Diameter 20 — 55 mm



Boundary Dimensions (mm)			Basic Load Ratings (N)				Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers
$D_C, D_{P1}$	$D_C, D_P$	$T_1$	$C_a$	$C_{oa}$	$C_a$	$C_{oa}$		
20	35	2.8	9 450	34 500	965	3 550	13 000	FB502002
30	47	2.8	12 700	56 500	1 300	5 750	9 000	FB503002
35	53	2.8	15 600	77 000	1 590	7 850	8 000	FB503503
40	60	2.8	20 200	112 000	2 060	11 400	7 100	FB504001
45	65	2.8	20 400	117 000	2 080	11 900	6 300	FB504501
50	70	2.8	21 200	126 000	2 160	12 800	6 000	FB505002
55	75	2.8	22 500	140 000	2 290	14 300	5 600	FB505501

Note (1) For tolerance classes E11, please refer to pages C60.

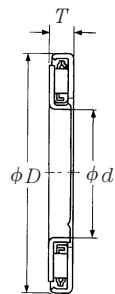
Matching Bearing Rings					Roller Contact Surfaces (mm)		Mass (g) approx
$s = 1.0 \pm 0.05$	$s = 1.5 \begin{smallmatrix} 0 \\ -0.08 \end{smallmatrix}$	$s = 2.0 \begin{smallmatrix} 0 \\ -0.08 \end{smallmatrix}$	$s = 2.5 \begin{smallmatrix} 0 \\ -0.08 \end{smallmatrix}$	$s = 3.0 \begin{smallmatrix} 0 \\ -0.08 \end{smallmatrix}$	$D_e$ min	$D_i$ max	
FTRA-2035	FTRB-2035	FTRC-2035	FTRD-2035	FTRE-2035	31	21	13
FTRA-3047	FTRB-3047	FTRC-3047	FTRD-3047	FTRE-3047	43	31	16
FTRA-3553	FTRB-3553	FTRC-3553	FTRD-3553	FTRE-3553	48.5	36.5	19
FTRA-4060	FTRB-4060	FTRC-4060	FTRD-4060	FTRE-4060	55	41	25
FTRA-4565	FTRB-4565	FTRC-4565	FTRD-4565	FTRE-4565	60.5	46	27
FTRA-5070	FTRB-5070	FTRC-5070	FTRD-5070	FTRE-5070	65.5	51	30
FTRA-5575	FTRB-5575	FTRC-5575	FTRD-5575	FTRE-5575	70.5	56	32

Thrust Needle Bearings

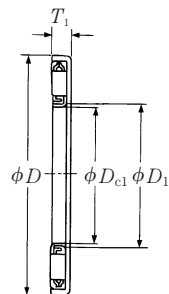
FH (With Integrated Raceway Washers)

FG

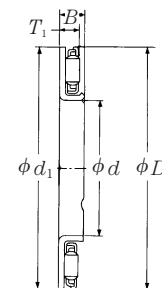
Bore Diameter 22.6 — 43 mm



Example 1



Example 2



Example 3

$d, D_1$	Boundary Dimensions (mm)					Basic Load Ratings (N) {kgf}			
	$D_{c1}$	$D, d_1$	$D_c$	$T, T_1$	$B$	$C_a$	$C_{oa}$	$C_a$	$C_{oa}$
<b>22.6</b>	—	38.7	—	3.894	—	10 100	40 000	1 030	4 100
<b>27.7</b>	—	45.9	—	3.604	—	15 300	71 000	1 560	7 250
<b>36</b>	—	53	—	3.8	—	13 700	66 000	1 400	6 700
<b>39.35</b>	—	54.02	—	3.604	—	11 400	52 500	1 160	5 350
<b>48.8</b>	—	70	—	4	—	20 300	120 000	2 070	12 200
<b>58.5</b>	—	78	—	4	—	20 400	125 000	2 080	12 800
<b>64.4</b>	—	78.1	—	4	—	10 200	52 500	1 040	5 350
<b>26.2</b>	28.575	46.32	—	3.81	—	19 800	74 500	2 020	7 600
<b>30</b>	30	47	—	2.824	—	12 700	56 500	1 300	5 750
<b>35</b>	35	53	—	2.824	—	15 600	77 000	1 590	7 850
<b>38.5</b>	38	57.3	—	2.81	—	15 600	78 000	1 590	7 950
<b>42</b>	42	61.98	—	3.81	—	24 700	110 000	2 520	11 200
<b>45</b>	45	64	—	2.8	—	20 400	117 000	2 080	11 900
<b>48.4</b>	48.4	68.48	—	3.81	—	25 000	117 000	2 550	11 900
<b>52</b>	52	72.1	—	2.81	—	21 000	126 000	2 140	12 800
<b>58</b>	58	78	—	2.8	—	23 300	149 000	2 380	15 200
<b>19</b>	—	45	45	2.794	3.43	13 200	60 000	1 340	6 100
<b>28</b>	—	52.5	52	2.81	3.43	17 200	88 000	1 760	8 950
<b>30.5</b>	—	48	48	2.794	3.43	13 400	63 000	1 370	6 450
<b>33.5</b>	—	47.8	48	2.794	3.43	13 400	63 000	1 370	6 450
<b>43</b>	—	60	60.05	2.8	3.43	16 900	91 500	1 720	9 350

Limiting Speeds (min <sup>-1</sup> )	Bearing Numbers	Example	Mass (g)
			approx
Oil			
11 000	<b>FH502201A</b> <b>FH502702A</b> <b>FH503604-1</b>	1	16.5
9 000		1	20.2
8 000		1	24.1
7 500	<b>FH503901A</b> <b>FH504801</b> <b>FH505802</b> <b>FH506401</b>	1	20.5
6 000		1	42.4
5 300		1	44.6
5 300	<b>FG502602</b> <b>FG503006</b> <b>FG503502</b>	1	32.7
9 000		2	20.2
9 000		2	14.8
8 000	<b>FG503804</b> <b>FG504201</b> <b>FG504501</b>	2	18.2
7 500		2	20.9
6 700		2	31.7
6 300	<b>FG504801</b> <b>FG505203</b> <b>FG505801</b>	2	23.2
6 000		2	35.5
5 600		2	28.1
5 300	<b>FG501903</b> <b>FG502801</b> <b>FG503002</b>	2	31.8
9 000		3	19.8
7 500		3	23
8 500	<b>FG503301</b> <b>FG504302</b>	3	16.3
8 500		3	14.1
6 700		3	20.9

## CAM FOLLOWERS (STUD TYPE TRACK ROLLERS)

Pages

Metric Design	Outside Diameter	10–90 mm .....	B182–B185
Inch Design	Outside Diameter	12.700–152.400 mm .....	B186–B189

Cam followers, which are equipped with a thick-wall outer ring, crowned rollers, and a stud with a hardened raceway surface, are especially tough and can sustain shock loads.

### Types

Cam followers are available in the standard types shown in **Table 1**. These standard bearings have a screwdriver slot built into the stud head, while the outer ring has a cylindrical outside surface.

Bearings of the following unique specifications are available for manufacture upon request:

1. Hexagonal socket of the stud head (refer to the Bearing Table)
2. Eccentric bush fixed to the stud to make it an eccentric stud (refer to the Bearing Table)
3. An outer ring with a spherical outside surface (refer to page B179)

These specifications are indicated in the bearing number. Please use the Formulation of Bearing Numbers as indicated on the following page when placing orders.

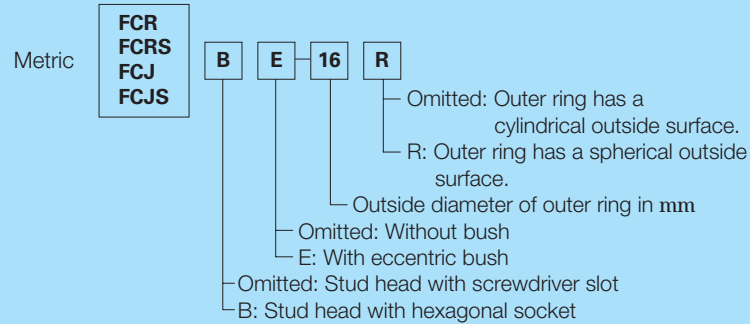
In addition to the above, products with their exposed surfaces treated with a black oxide layer to enhance corrosion resistance, as well as products of special shapes and specifications, can also be manufactured. Please contact NSK for further details.



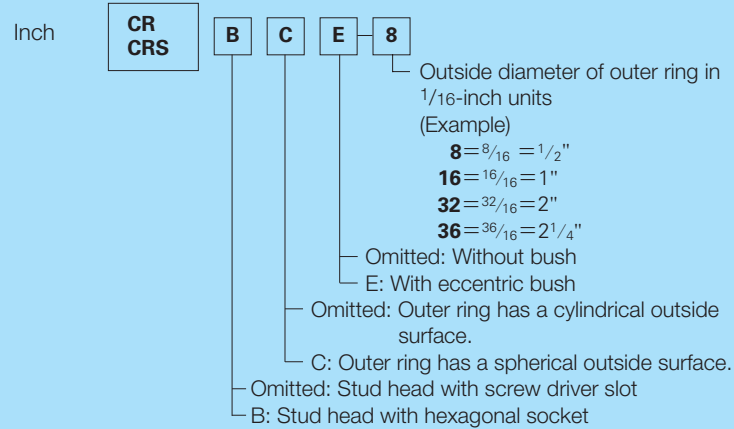
**Table 1 Bearing Types**

Code		Details
Metric	FCR	Full complement, without seal
	FCRS	Full complement, with seal, with thrust washer
	FCJ	With Cage, without seal
	FCJS	With Cage, with seal, with thrust washer
Inch	CR	Full complement
	CRS	Full complement, with seal, with thrust washer

**Formulation of Bearing Numbers**



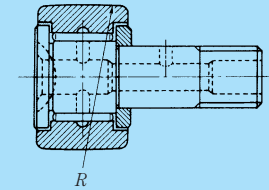
- (Example) FCRE-16** Full complement, with screwdriver slot, with eccentric bush, outside diameter of outer ring is 16 mm
- FCJSB-16** With cage, with seal/thrust washer, with hexagonal socket, outside diameter of outer ring is 16 mm
- FCRSBE-16R** Full complement, with seal/thrust washer, with hexagonal socket, with eccentric bush, outside diameter of outer ring is 16 mm and the outer ring has a spherical outside surface



- (Example) CRE-8** Full complement, with screwdriver slot, with eccentric bush, outside diameter of outer ring is 12.700 mm (8/16 inch)
- CRSB-8** Full complement, with seal/thrust washer, with hexagonal socket, outside diameter of outer ring is 12.700 mm (8/16 inch)
- CRSBCE-8** Full complement, with seal/thrust washer, with hexagonal socket, with eccentric bush, outside diameter of outer ring is 12.700 mm (8/16 inch) and the outer ring has a spherical outside surface

**Spherical Radius of Outer Ring Outside**

Spherical radii for metric bearings are shown in **Table 2** and for inch bearings in **Table 3**.



**Table 2 Spherical Radius, R, of Metric Bearings**

Units: mm	
Bearing Number	R
All Bearing Numbers	500

**Table 3 Spherical Radius, R, of Inch Bearings**

Units: mm					
Bearing Number (1)	R	Bearing Number (1)	R	Bearing Number (1)	R
CRC-8	150	CRC-20	360	CRC-40	760
CRC-8-1	180	CRC-22	360	CRC-44	760
CRC-10	180	CRC-24	500	CRC-48	760
CRC-10-1	200	CRC-26	500	CRC-52	760
CRC-12	250	CRC-28	500	CRC-56	760
CRC-14	250	CRC-30	500	CRC-64	760
CRC-16	300	CRC-32	600	CRC-80	1200
CRC-18	300	CRC-36	600	CRC-96	1400

**Note** (1) This uses CRC bearings as an example. However, since dimension series are the same, the R dimensions shown in the above table should also be applied to CRSC bearings.

**Accuracy**

NSK cam followers are manufactured with the dimensional tolerances shown in **Table 4**. Running accuracy is subject to ISO Class 0 and is always applied to the bearing before surface treatment.

**Table 4 Cam Follower Dimensional Tolerances**

Units: μm					
Type	Stud Diameter Deviation, Δdmp, or Fitting Tolerance	Single Plane Mean Outside Diameter Deviation, ΔDmp		Deviation of Outer Ring Width C, ΔCs	
		Cylindrical Outside	Spherical Outside		
Metric	FCR, FCRS, FCJ, FCJS	h7	According to ISO Class 0	0 -50	According to ISO Class 0
Inch	CR, CRS	+25 0	0 -25	0 -50	0 -130

## Accessories

NSK cam followers include a sealing plug but the nut, washer and grease nipple are available as accessories. When ordering, please add the part code shown in **Table 5** after the bearing number.

**Table 5 Part Code of Accessories**

Type	Sealing Plug	Grease	Nut	Washer	Nipple
FCR, FCJ, CR	Included	Not pre-packed	I	N	Z
FCRS, FCJS, CRS	Included	pre-packed			

**[Example] FCR-16 + I N Z**

I — Nut  
 N — Washer  
 Z — Nipple

## Applications

### Fitting

The recommended fittings for the mounting area of cam follower studs are shown in **Table 6**. Since cam followers use cantilever mounting, the fitting for the stud and mounting hole should be assembled with as little play as possible. In case there is interference in the fitting of the stud and mounting hole, the center of the stud end should be inserted with a press. The side plate should be securely fixed onto the plane surface square to the center axis, without play. In order to get a sufficient support face for the side plate, the dimension of the shoulder should be larger than the value of  $F$  shown in the bearing table. Play in the mounting part should be avoided because it would not only cause inclination to the stud but also create considerable deflection when a load is imposed. The load would also be unevenly imposed on the rollers due to edge contact between the outer ring and track (on which the outer ring runs).

**Table 6 Recommended Fitting for Stud Mounting Part**

Type		Fitting Tolerance of Mounting Hole
Metric	FCR, FCJ, FCRS, FCJS	JS7 (J7)
Inch	CR, CRS	F7

### Maximum Permissible Load

The maximum radial load that the cam follower can carry is determined by the bearing strength and shear strength of the stud rather than the load rating for needle bearings. This value is given in the bearing table as the maximum permissible load.

The cam follower can deliver a performance of the maximum strength of stud by mounting securely to the side plate so as to minimize overhang. It is necessary, therefore, to minimize chamfering at the corner of the stud mounting hole and avoid burrs.

### Permissible Track Load

The permissible load of the track is determined by compression strength or hardness. The permissible load of the track shown in the bearing table is the value of a track made of steel with a hardness of HRC40.

**Table 7** indicates the permissible load coefficient of the track for each hardness.

The permissible load of the track for each hardness can be obtained by multiplying the permissible load of the track shown in the bearing table by the permissible load coefficient of the track corresponding to each hardness.

**Table 7 Permissible Load Coefficient of Track**

Hardness (HRC)	Coefficient
20	0.4
25	0.5
30	0.6
35	0.8
40	1.0
45	1.4
50	1.9
55	2.6
58	3.2

### Maximum Clamp Torque

Since the stud of the cam follower receives bending stress and tensile stress from the bearing load, the screw clamp torque should not exceed the value shown in the bearing table. The clamp torque (maximum) in the bearing table is the value when the thread is lubricated and the value when dry should be approximately doubled.

### Pre-packed Grease

The cam follower with a seal is pre-lubricated with lithium soap-based grease and the working temperature range is -10 to +110°C.

CAM FOLLOWERS

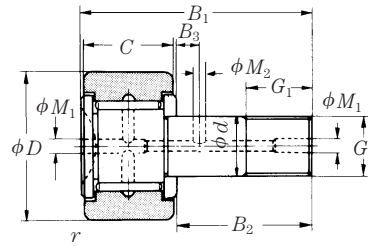
FCR (Full Complement)

FCRS (Full Complement, Sealed, With Thrust Washer)

FCJ (With Cage)

FCJS (Sealed, With Cage and Thrust Washer)

Outside Diameter 10 – 62 mm

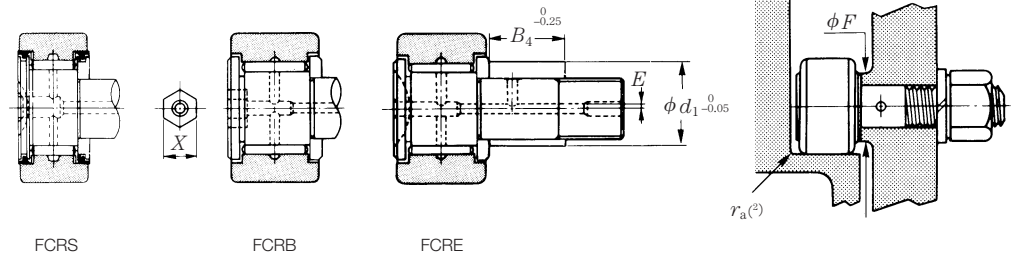


FCR

Boundary Dimensions (mm)			Dimensions (mm)								Bearing Numbers		
D	C	d	Screw G	G <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	M <sub>2</sub>	M <sub>1</sub>	r min	FCR FCJ	FCRS FCJS	
10	7	3	M3X0.5	5	17	9	—	—	—	0.3	<b>FCJB-10</b>		
12	8	4	M4X0.7	6	20	11	—	—	—	0.3	<b>FCJ-12</b>		
	8	4	M4X0.7	6	20	11	—	—	—	0.3	<b>FCJB-12</b>		
16	11	6	M6X1.0	8	28	16	—	—	4 <sup>(1)</sup>	0.3	<b>FCR-16</b>	<b>FCRS-16</b>	
	11	6	M6X1.0	8	28	16	—	—	4 <sup>(1)</sup>	0.3	<b>FCJ-16</b>	<b>FCJS-16</b>	
19	11	8	M8X1.25	10	32	20	—	—	4 <sup>(1)</sup>	0.3	<b>FCR-19</b>	<b>FCRS-19</b>	
	11	8	M8X1.25	10	32	20	—	—	4 <sup>(1)</sup>	0.3	<b>FCJ-19</b>	<b>FCJS-19</b>	
22	12	10	M10X1.25	12	36	23	—	—	4 <sup>(1)</sup>	0.3	<b>FCR-22</b>	<b>FCRS-22</b>	
	12	10	M10X1.25	12	36	23	—	—	4 <sup>(1)</sup>	0.3	<b>FCJ-22</b>	<b>FCJS-22</b>	
26	12	10	M10X1.25	12	36	23	—	—	4 <sup>(1)</sup>	0.3	<b>FCR-26</b>	<b>FCRS-26</b>	
	12	10	M10X1.25	12	36	23	—	—	4 <sup>(1)</sup>	0.3	<b>FCJ-26</b>	<b>FCJS-26</b>	
30	14	12	M12X1.5	13	40	25	6	3	6	0.6	<b>FCR-30</b>	<b>FCRS-30</b>	
	14	12	M12X1.5	13	40	25	6	3	6	0.6	<b>FCJ-30</b>	<b>FCJS-30</b>	
32	14	12	M12X1.5	13	40	25	6	3	6	0.6	<b>FCR-32</b>	<b>FCRS-32</b>	
	14	12	M12X1.5	13	40	25	6	3	6	0.6	<b>FCJ-32</b>	<b>FCJS-32</b>	
35	18	16	M16X1.5	17	52	32.5	8	3	6	0.6	<b>FCR-35</b>	<b>FCRS-35</b>	
	18	16	M16X1.5	17	52	32.5	8	3	6	0.6	<b>FCJ-35</b>	<b>FCJS-35</b>	
40	20	18	M18X1.5	19	58	36.5	8	3	6	1	<b>FCR-40</b>	<b>FCRS-40</b>	
	20	18	M18X1.5	19	58	36.5	8	3	6	1	<b>FCJ-40</b>	<b>FCJS-40</b>	
47	24	20	M20X1.5	21	66	40.5	9	4	8	1	<b>FCR-47</b>	<b>FCRS-47</b>	
	24	20	M20X1.5	21	66	40.5	9	4	8	1	<b>FCJ-47</b>	<b>FCJS-47</b>	
52	24	20	M20X1.5	21	66	40.5	9	4	8	1	<b>FCR-52</b>	<b>FCRS-52</b>	
	24	20	M20X1.5	21	66	40.5	9	4	8	1	<b>FCJ-52</b>	<b>FCJS-52</b>	
62	29	24	M24X1.5	25	80	49.5	11	4	8	1	<b>FCR-62</b>	<b>FCRS-62</b>	
	29	24	M24X1.5	25	80	49.5	11	4	8	1	<b>FCJ-62</b>	<b>FCJS-62</b>	

**Note** <sup>(1)</sup> Only the head of the stud has an oil hole.  
**Remarks** Standard grease is packed in sealed cam followers, but not in cam followers without seals.

NSK NEEDLE BEARING



FCRS

FCRB

FCRE

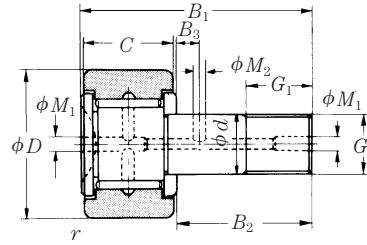
\*1 Dimensions of Hexagonal Socked (width across flats) <sup>(3)</sup>  
 \*2 Shoulder Dimensions

Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}		Limiting Track Loads (N) {kgf}		Mass (kg)	*1 (mm)	Eccentric Bush Dimensions (mm) <sup>(4)</sup>			*2 (mm)	Tightening Torque <sup>(5)</sup> (N·cm) {kgf·cm}	
C <sub>r</sub>		P <sub>max</sub>				approx	X	B <sub>1</sub>	d <sub>1</sub>	E	F <sub>min</sub>	max	max
1 390	142	590	60	1 320	135	0.005	2.5	—	—	—	7.5	28	2.9
1 970	201	1 050	107	1 860	190	0.008	—	—	—	9	64	6.5	6.5
1 970	201	1 050	107	1 860	190	0.008	2.5	—	—	—	9	64	6.5
5 800	590	2 360	240	3 350	340	0.020	4	8	9	0.5	11	226	23
2 830	288	2 360	240	3 350	340	0.018	4	8	9	0.5	11	226	23
6 600	670	4 200	425	4 150	425	0.031	4	10	11	0.5	13	550	56
3 450	355	4 200	425	4 150	425	0.030	4	10	11	0.5	13	550	56
8 550	875	6 550	665	5 300	540	0.047	5	11	13	0.5	15	1 060	108
4 350	445	6 550	665	5 300	540	0.045	5	11	13	0.5	15	1 060	108
8 550	875	6 550	665	6 000	610	0.060	5	11	13	0.5	15	1 060	108
4 350	445	6 550	665	6 000	610	0.058	5	11	13	0.5	15	1 060	108
12 500	1 280	9 250	945	7 800	795	0.088	6	12	17	1	20	1 450	148
7 200	735	9 250	945	7 800	795	0.086	6	12	17	1	20	1 450	148
12 500	1 280	9 250	945	8 050	820	0.099	6	12	17	1	20	1 450	148
7 200	735	9 250	945	8 050	820	0.096	6	12	17	1	20	1 450	148
18 600	1 900	17 000	1 740	11 800	1 200	0.17	10	15.5	22	1	24	4 000	410
9 700	990	17 000	1 740	11 800	1 200	0.165	10	15.5	22	1	24	4 000	410
20 500	2 090	21 700	2 220	14 300	1 460	0.25	10	17.5	24	1	26	5 950	605
10 300	1 050	21 700	2 220	14 300	1 460	0.24	10	17.5	24	1	26	5 950	605
28 200	2 880	26 400	2 690	20 800	2 120	0.39	12	19.5	27	1	31	8 450	860
19 200	1 950	26 400	2 690	20 800	2 120	0.38	12	19.5	27	1	31	8 450	860
28 200	2 880	26 400	2 690	22 900	2 340	0.47	12	19.5	27	1	31	8 450	860
19 200	1 950	26 400	2 690	22 900	2 340	0.455	12	19.5	27	1	31	8 450	860
40 000	4 100	38 500	3 950	34 000	3 450	0.80	14	24.5	34	1	45	15 200	1 550
24 900	2 540	38 500	3 950	34 000	3 450	0.79	14	24.5	34	1	45	15 200	1 550

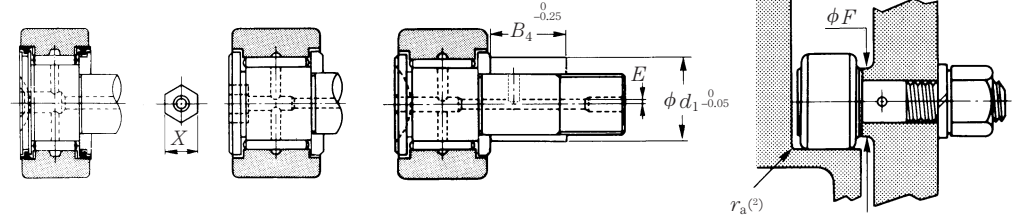
**Notes** <sup>(2)</sup> Should not be greater than r<sub>min</sub>.  
<sup>(3)</sup> Applicable to FCRB only.  
<sup>(4)</sup> Applicable to FCRE only.  
<sup>(5)</sup> These values are for when the screw is oiled; they should be approximately doubled when the screw is dry.

CAM FOLLOWERS

- FCR (Full Complement)
- FCRS (Full Complement, Sealed, With Thrust Washer)
- FCJ (With Cage)
- FCJS (Sealed, With Cage and Thrust Washer)
- Outside Diameter 72 – 90 mm



FCR



FCRS

FCRB

FCRE

Boundary Dimensions (mm)			Dimensions (mm)								Bearing Numbers	
D	C	d	Screw G	G <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	M <sub>2</sub>	M <sub>1</sub>	r min	FCR FCJ	FCRS FCJS
72	29	24	M24X1.5	25	80	49.5	11	4	8	1	FCR-72 FCJ-72	FCRS-72 FCJS-72
	29	24	M24X1.5	25	80	49.5	11	4	8	1		
80	35	30	M30X1.5	32	100	63	15	4	8	1	FCR-80 FCJ-80	FCRS-80 FCJS-80
	35	30	M30X1.5	32	100	63	15	4	8	1		
85	35	30	M30X1.5	32	100	63	15	4	8	1	FCR-85 FCJ-85	FCRS-85 FCJS-85
	35	30	M30X1.5	32	100	63	15	4	8	1		
90	35	30	M30X1.5	32	100	63	15	4	8	1	FCR-90 FCJ-90	FCRS-90 FCJS-90
	35	30	M30X1.5	32	100	63	15	4	8	1		

Remarks Standard grease is packed in sealed cam followers, but not in cam followers without seals.

\*1 Dimensions of Hexagonal Socked (width across flats) (3)  
\*2 Shoulder Dimensions

Basic Dynamic Load Ratings (N) (kgf)		Limiting Loads (N) (kgf)		Limiting Track Loads (N) (kgf)		Mass (kg)	*1 (mm)	Eccentric Bush Dimensions (mm) (4)			*2 (mm)	Tightening Torque (5) (N·cm) (kgf·cm)	
C <sub>r</sub>		P <sub>max</sub>				approx	X	B <sub>1</sub>	d <sub>1</sub>	E	F min	max	max
40 000	4 100	38 500	3 950	38 000	3 860	1.05	14	24.5	34	1	45	15 200	1 550
24 900	2 540	38 500	3 950	38 000	3 860	1.05	14	24.5	34	1	45	15 200	1 550
60 500	6 200	61 000	6 200	52 000	5 300	1.55	17	31	40	1.5	52	30 500	3 120
39 000	4 000	61 000	6 200	52 000	5 300	1.55	17	31	40	1.5	52	30 500	3 120
60 500	6 200	61 000	6 200	55 500	5 650	1.75	17	31	40	1.5	52	30 500	3 120
39 000	4 000	61 000	6 200	55 500	5 650	1.75	17	31	40	1.5	52	30 500	3 120
60 500	6 200	61 000	6 200	59 000	6 000	1.95	17	31	40	1.5	52	30 500	3 120
39 000	4 000	61 000	6 200	59 000	6 000	1.95	17	31	40	1.5	52	30 500	3 120

- Notes (2) Should not be greater than r<sub>(min)</sub>.
- (3) Applicable to FCRB only.
- (4) Applicable to FCRE only.
- (5) These values are for when the screw is oiled; they should be approximately doubled when the screw is dry.

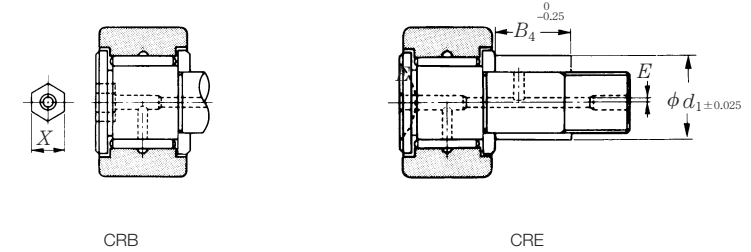
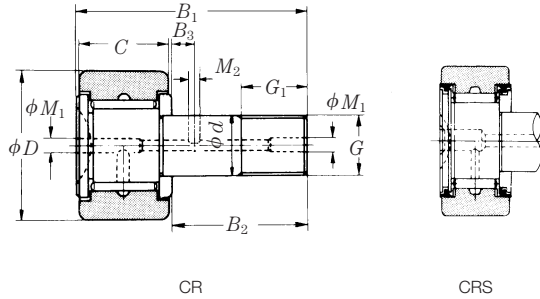


CAM FOLLOWERS (INCH DESIGN)

CR (Full Complement)

CRS (Full Complement, Sealed, With Thrust Washer)

Outside Diameter 12.700 – 152.4 mm



Boundary Dimensions (mm, inch)				Dimensions (mm)							
D	C	d		Screw UNF G	G <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	M <sub>2</sub>	M <sub>1</sub>	
12.700	0.5000	8.74	4.826	—	10-32	6.4	22.8	12.70	—	—	3.2 <sup>(3)</sup>
		9.52	4.826	—	10-32	6.4	26.8	15.88	—	—	3.2 <sup>(3)</sup>
15.875	0.6250	10.31	6.350	0.2500	1/4-28	7.9	27.3	15.88	—	—	3.2 <sup>(3)</sup>
		11.13	6.350	0.2500	1/4-28	7.9	31.3	19.05	—	—	3.2 <sup>(3)</sup>
19.050	0.7500	12.70	9.525	0.3750	3/8-24	9.5	36.1	22.22	6.35	2.4	4.8
22.225	0.8750	12.70	9.525	0.3750	3/8-24	9.5	36.1	22.22	6.35	2.4	4.8
25.400	1.0000	15.88	11.112	0.4375	7/16-20	12.7	42.4	25.40	6.35	3.2	4.8
28.575	1.1250	15.88	11.112	0.4375	7/16-20	12.7	42.4	25.40	6.35	3.2	4.8
31.750	1.2500	19.05	12.700	0.5000	1/2-20	15.9	52.2	31.75	7.94	3.2	4.8
34.925	1.3750	19.05	12.700	0.5000	1/2-20	15.9	52.2	31.75	7.94	3.2	4.8
38.100	1.5000	22.22	15.875	0.6250	5/8-18	19.0	61.6	38.10	9.52	4.0	4.8
41.275	1.6250	22.22	15.875	0.6250	5/8-18	19.0	61.6	38.10	9.52	4.0	4.8
44.450	1.7500	25.40	19.050	0.7500	3/4-16	22.2	71.2	44.45	11.11	4.0	4.8
47.625	1.8750	25.40	19.050	0.7500	3/4-16	22.2	71.2	44.45	11.11	4.0	4.8
50.800	2.0000	31.75	22.225	0.8750	7/8-14	25.4	83.9	50.80	12.70	4.8	4.8
57.150	2.2500	31.75	22.225	0.8750	7/8-14	25.4	83.9	50.80	12.70	4.8	4.8
63.500	2.5000	38.10	25.400	1.0000	1-14 <sup>(1)</sup>	28.6	96.9	57.15	14.29	4.8	4.8
69.850	2.7500	38.10	25.400	1.0000	1-14 <sup>(1)</sup>	28.6	96.9	57.15	14.29	4.8	4.8
76.200	3.0000	44.45	31.750	1.2500	1 1/4-12	31.8	109.6	63.50	15.88	4.8	6.4
82.550	3.2500	44.45	31.750	1.2500	1 1/4-12	31.8	109.6	63.50	15.88	4.8	6.4
88.900	3.5000	50.80	34.925	1.3750	1 3/8-12	34.9	122.3	69.85	17.46	4.8	6.4
101.600	4.0000	57.15	38.100	1.5000	1 1/2-12	38.1	147.7	88.90	19.05	4.8	6.4
127.000	5.0000	69.85	50.800	2.0000	2-12 <sup>(2)</sup>	65.1	200.9	128.59	22.22	4.8	6.4
152.400	6.0000	82.55	63.500	2.5000	2 1/2-12 <sup>(2)</sup>	76.2	237.5	152.40	25.40	4.8	6.4

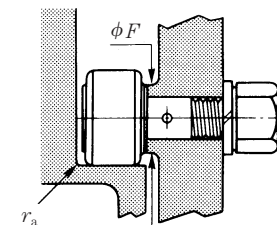
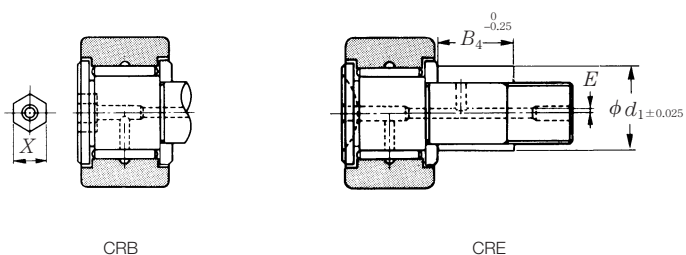
Notes (1) USN screws are used in place of UNF screws.  
 (2) UN screws are used in place of UNF screws.  
 (3) Only the head of the stud has an oil hole.

Remarks Standard grease is packed in sealed cam followers, but not in cam followers without seals.

NSK NEEDLE BEARING

Bearing Numbers		Basic Dynamic Load Ratings (N) {kgf}		Limiting Loads (N) {kgf}		Limiting Track Loads (N) {kgf}	
CR	CRS	C <sub>r</sub>		P <sub>max</sub>			
CR-8	CRS-8	3 800	385	1 340	136	2 050	209
CR-8-1	CRS-8-1	4 200	430	1 340	136	2 260	230
CR-10	CRS-10	5 350	545	2 640	269	2 920	298
CR-10-1	CRS-10-1	5 800	595	2 640	269	3 200	325
CR-12	CRS-12	8 850	900	5 900	600	4 550	465
CR-14	CRS-14	8 850	900	5 900	600	5 150	525
CR-16	CRS-16	11 200	1 140	6 950	710	6 550	670
CR-18	CRS-18	11 200	1 140	6 950	710	7 450	760
CR-20	CRS-20	18 500	1 890	9 600	975	10 400	1 060
CR-22	CRS-22	18 500	1 890	9 600	975	11 500	1 170
CR-24	CRS-24	21 700	2 220	15 900	1 620	15 000	1 530
CR-26	CRS-26	21 700	2 220	15 900	1 620	16 300	1 660
CR-28	CRS-28	27 700	2 830	23 600	2 400	20 000	2 040
CR-30	CRS-30	27 700	2 830	23 600	2 400	21 500	2 190
CR-32	CRS-32	41 500	4 250	32 500	3 350	29 100	2 970
CR-36	CRS-36	41 500	4 250	32 500	3 350	33 000	3 350
CR-40	CRS-40	52 500	5 350	43 000	4 400	41 000	4 200
CR-44	CRS-44	52 500	5 350	43 000	4 400	45 500	4 650
CR-48	CRS-48	76 000	7 750	67 000	6 850	60 000	6 100
CR-52	CRS-52	76 000	7 750	67 000	6 850	64 500	6 600
CR-56	CRS-56	99 000	10 100	81 500	8 350	81 500	8 300
CR-64	CRS-64	126 000	12 800	98 000	9 950	107 000	10 900
CRB-80	CRSB-80	198 000	20 200	176 000	18 000	154 000	15 700
CRB-96	CRSB-96	283 000	28 800	277 000	28 200	226 000	23 000

Abutment and fillet dimensions, and tightening torque are shown on the next page.



\*1 Dimensions of Hexagonal Socked (width across flats) (\*)

Boundary Dimensions		Mass (kg) approx	*1 (mm) X	Eccentric Bush Dimensions (mm) (°)		
CR	CRS			B <sub>4</sub>	d <sub>1</sub>	E
<b>CR-8</b>	<b>CRS-8</b>	0.010	3.18	—	—	—
<b>CR-8-1</b>	<b>CRS-8-1</b>	0.010	3.18	9.52	6.350	0.25
<b>CR-10</b>	<b>CRS-10</b>	0.019	3.18	—	—	—
<b>CR-10-1</b>	<b>CRS-10-1</b>	0.020	3.18	11.10	9.525	0.38
<b>CR-12</b>	<b>CRS-12</b>	0.034	4.76	12.70	12.700	0.38
<b>CR-14</b>	<b>CRS-14</b>	0.044	4.76	12.70	12.700	0.38
<b>CR-16</b>	<b>CRS-16</b>	0.073	6.35	12.70	15.875	0.76
<b>CR-18</b>	<b>CRS-18</b>	0.089	6.35	12.70	15.875	0.76
<b>CR-20</b>	<b>CRS-20</b>	0.135	6.35	15.88	17.450	0.76
<b>CR-22</b>	<b>CRS-22</b>	0.16	6.35	15.88	17.450	0.76
<b>CR-24</b>	<b>CRS-24</b>	0.24	7.94	19.05	22.225	0.76
<b>CR-26</b>	<b>CRS-26</b>	0.275	7.94	19.05	22.225	0.76
<b>CR-28</b>	<b>CRS-28</b>	0.385	7.94	22.22	25.400	0.76
<b>CR-30</b>	<b>CRS-30</b>	0.43	7.94	22.22	25.400	0.76
<b>CR-32</b>	<b>CRS-32</b>	0.62	11.11	25.40	30.150	0.76
<b>CR-36</b>	<b>CRS-36</b>	0.755	11.11	25.40	30.150	0.76
<b>CR-40</b>	<b>CRS-40</b>	1.15	12.70	28.58	34.925	0.76
<b>CR-44</b>	<b>CRS-44</b>	1.35	12.70	28.58	34.925	0.76
<b>CR-48</b>	<b>CRS-48</b>	1.9	15.88	31.75	44.450	1.52
<b>CR-52</b>	<b>CRS-52</b>	2.2	15.88	31.75	44.450	1.52
<b>CR-56</b>	<b>CRS-56</b>	2.9	15.88	34.92	46.025	1.52
<b>CR-64</b>	<b>CRS-64</b>	4.3	19.05	50.80	50.800	1.52
<b>CRB-80</b>	<b>CRSB-80</b>	8.7	22.22	—	—	—
<b>CRB-96</b>	<b>CRSB-96</b>	15	25.40	—	—	—

Notes (\*) Applicable to CRB only.  
(°) Applicable to CRE only.

\*2 Fillet Radius of Housing

Shoulder Dimensions (mm) F min	*2 (mm) r <sub>a</sub> min	Tightening Torque (°)	
		(N·cm) max	{kgf·cm} max
7.5	0.25	90	9.2
7.5	0.25	90	9.2
9.1	0.4	226	23
9.1	0.4	226	23
12.7	0.4	630	64
12.7	0.4	630	64
15.1	0.8	1 700	173
15.1	0.8	1 700	173
19.0	0.8	2 310	236
19.0	0.8	2 310	236
22.6	0.8	4 400	450
22.6	0.8	4 400	450
26.6	1	8 500	865
26.6	1	8 500	865
30.6	1.3	10 200	1040
30.6	1.3	10 200	1040
34.9	2.3	15 300	1560
34.9	2.3	15 300	1560
44.4	2.3	23 100	2360
44.4	2.3	23 100	2360
48.8	2.3	28 200	2880
57.9	2.3	34 000	3450
82.6	4	34 000	3450
99.2	4	34 000	3450

Notes (°) These values are for when the screw is oiled; they should be approximately doubled when the screw is dry.

## ROLLER FOLLOWERS (YOKE TYPE TRACK ROLLERS)

Pages

Metric Design	Bore Diameter	5-50 mm	.....	B194-B195
Inch Design	Bore Diameter	6.350-57.150 mm	.....	B196-B197

The roller follower with a thick-wall outer ring and crowned roller has a large load capacity which enables it to carry shock loads. Handling is easy since it is non-separating and applications such as track rollers, cams and rocker arms are wide.

### Types

NSK roller followers are available in the types shown in **Table 1**. All of the bearings in **Table 1** have a cylindrical outside. Bearings of the following specifications are available and can be manufactured upon request:

- Outer ring with a spherical exterior

In this case, your order should be placed in the following manner:  
 (1) For metric bearings, **R** should be added to the end of bearing number.

Examples: **FYCR-5R, FYCJ-5R**  
**FYCRS-5R, FYCJS-5R**

- For inch bearings, **C** should be added to the end of the bearing type code.

Examples: **YCRC-12**  
**YCRSC-12**

Spherical radius of outer ring is shown in page B193.

- Exposed surface treated with a black oxide layer

In addition to the above, products of special shape and specifications are available and can be manufactured upon order. Please contact NSK for further details.



**Table 1 Bearing Types**

Type		Details
Metric	FYCR	Full complement
	FYCRS	With seal, full complement, with thrust washer
	FYCJ	With cage
	FYCJS	With seal, with cage, with thrust washer
Inch	YCR	Full complement
	YCRS	With seal, full complement, with thrust washer

**Accuracy**

NSK metric roller followers are manufactured in compliance with ISO Class 0 (refer to pages A26 and A27), and inch followers in compliance with the tolerances shown in **Table 2**. Running accuracy complies with ISO Class 0 in both cases.

The deviations for the above apply to the bearings before surface treatment.

**Table 2 Tolerances for Inch Bearings**

Units:  $\mu\text{m}$

Nominal Bore Diameter, $d$ (mm)		Single Plane Mean Bore Diameter Deviation, $\Delta d_{mp}$		Single Plane Mean Outside Diameter Deviation, $\Delta D_{mp}$				Outer Ring Width Deviation, $\Delta C_s$		Overall Inner Ring Width Deviation, $\Delta B_s$	
				Cylindrical Outside Surface		Spherical Outside Surface (*)					
over	incl	high	low	high	low	high	low	high	low	high	low
—	19.05	+5	-10	0	-25	0	-50	0	-130	+130	-256
19.05	57.15	+2	-13	0	-25	0	-50	0	-130	+130	-250

**Note** (\*) Metric bearings have the same dimension tolerance.

**Applications**

**Fitting**

Roller followers are generally used with a transition or loose fit for the shaft because their outer ring rotates. With heavy loads, however, it is recommended to harden the shaft and use it with a tight fit. In order to prevent the bearing from moving in the axial direction, both ends of the inner ring should be securely fixed to the plane surface, square to the center axis. In order to sufficiently support the side plate, the dimension of the shoulder should be larger than the value of  $R$  in the bearing table.

Recommended fittings are shown in **Table 3**.

**Table 3 Recommended Shaft Fittings**

Load	Fitting Tolerance of Shaft
Light Load/Normal Load	g6 or h6
Heavy Load	k6

**Permissible Track Load**

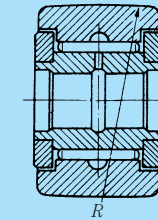
Permissible track load values are the same as those for cam followers. Please refer to the explanation on permissible track load on page B181.

**Pre-Packed Grease**

Roller followers with seals are pre-lubricated with lithium soap-based grease and the working temperature range is -10 to +110°C.

**Spherical Radius of Outer Ring Outside**

Spherical radii for metric bearings are shown in **Table 4** and for inch bearings in **Table 5**.



**Table 4 Spherical Radius,  $R$ , of Metric Bearing Outside**

Units: mm

Bearing Number	$R$
All Bearing Numbers	500

**Table 5 Spherical Radius,  $R$ , of Inch Bearing Outside**

Units: mm

Bearing Number (*)	$R$	Bearing Number (*)	$R$
YCRC-12	250	YCRC-32	600
YCRC-14	250	YCRC-36	600
YCRC-16	300	YCRC-40	760
YCRC-18	300	YCRC-44	760
YCRC-20	360	YCRC-48	760
YCRC-22	360	YCRC-52	760
YCRC-24	500	YCRC-56	760
YCRC-26	500	YCRC-64	760
YCRC-28	500	YCRC-80	1200
YCRC-30	500	YCRC-96	1400

**Note** (\*) While YCRC bearing numbers are listed here, the values of  $R$  also apply to YCRSC bearings.

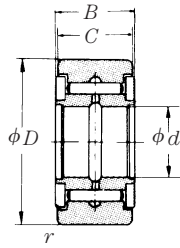
**FYCR (Full Complement)**

**FYCRS (Full Complement, Sealed,  
With Thrust Washer)**

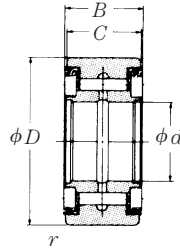
**FYCJ (With Cage)**

**FYCJS (Sealed, With Cage and  
Thrust Washer)**

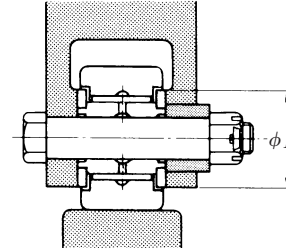
**Bore Diameter 5 – 50 mm**



FYCR



FYCRS



d	Boundary Dimensions (mm)				Basic Load Ratings (N) {kgf}				Limiting Track Loads (N) {kgf}	
	D	C	B <sub>-0.38</sub>	r <sub>min</sub>	C <sub>r</sub>	C <sub>or</sub>	C <sub>r</sub>	C <sub>or</sub>		
5	16	11	12	0.3	5 800	8 000	590	815	3 350	340
	16	11	12	0.3	2 830	2 620	288	267	3 350	340
6	19	11	12	0.3	6 550	9 900	665	1 010	4 150	425
	19	11	12	0.3	3 450	3 600	355	365	4 150	425
8	24	14	15	0.3	10 100	15 000	1 030	1 530	6 500	665
	24	14	15	0.3	5 700	6 000	580	610	6 500	665
10	30	14	15	0.6	11 700	18 500	1 190	1 890	7 800	795
	30	14	15	0.6	6 950	8 200	705	835	7 800	795
12	32	14	15	0.6	12 600	21 000	1 280	2 140	8 050	820
	32	14	15	0.6	7 650	9 650	780	985	8 050	820
15	35	18	19	0.6	18 700	29 300	1 910	2 990	11 800	1 200
	35	18	19	0.6	12 200	14 100	1 250	1 440	11 800	1 200
17	40	20	21	1	21 100	35 000	2 160	3 600	14 300	1 460
	40	20	21	1	13 700	16 700	1 390	1 700	14 300	1 460
20	47	24	25	1	28 900	50 000	2 940	5 100	20 800	2 120
	47	24	25	1	18 200	22 600	1 850	2 310	20 800	2 120
25	52	24	25	1	32 500	60 000	3 300	6 100	22 900	2 340
	52	24	25	1	22 200	31 000	2 270	3 150	22 900	2 340
30	62	28	29	1	47 500	96 000	4 800	9 800	33 000	3 350
	62	28	29	1	31 500	47 000	3 200	4 800	33 000	3 350
35	72	28	29	1	49 500	106 000	5 050	10 800	36 500	3 700
	72	28	29	1	33 000	52 500	3 400	5 350	36 500	3 700
40	80	30	32	1	54 500	126 000	5 600	12 800	43 500	4 450
	80	30	32	1	38 500	67 500	3 950	6 900	43 500	4 450
45	85	30	32	1	57 500	139 000	5 850	14 100	46 500	4 750
	85	30	32	1	40 000	73 000	4 100	7 450	46 500	4 750
50	90	30	32	1	60 500	152 000	6 150	15 500	49 500	5 050
	90	30	32	1	41 500	78 000	4 200	7 950	49 500	5 050

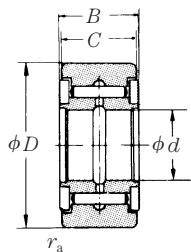
**Remarks** Standard grease is packed in sealed cam followers, but not in cam followers without seals.

Bearing Numbers		Mass (kg) approx	Shoulder Dimensions (mm) F <sub>min</sub>
FYCR FYCJ	FYCRS FYCJS		
<b>FYCR-5</b>	<b>FYCRS-5</b>	0.016	10
<b>FYCJ-5</b>	<b>FYCJS-5</b>	0.014	10
<b>FYCR-6</b>	<b>FYCRS-6</b>	0.022	12
<b>FYCJ-6</b>	<b>FYCJS-6</b>	0.020	12
<b>FYCR-8</b>	<b>FYCRS-8</b>	0.044	14
<b>FYCJ-8</b>	<b>FYCJS-8</b>	0.042	14
<b>FYCR-10</b>	<b>FYCRS-10</b>	0.069	17
<b>FYCJ-10</b>	<b>FYCJS-10</b>	0.067	17
<b>FYCR-12</b>	<b>FYCRS-12</b>	0.076	19
<b>FYCJ-12</b>	<b>FYCJS-12</b>	0.074	19
<b>FYCR-15</b>	<b>FYCRS-15</b>	0.105	23
<b>FYCJ-15</b>	<b>FYCJS-15</b>	0.097	23
<b>FYCR-17</b>	<b>FYCRS-17</b>	0.145	25
<b>FYCJ-17</b>	<b>FYCJS-17</b>	0.14	25
<b>FYCR-20</b>	<b>FYCRS-20</b>	0.255	29
<b>FYCJ-20</b>	<b>FYCJS-20</b>	0.245	29
<b>FYCR-25</b>	<b>FYCRS-25</b>	0.285	34
<b>FYCJ-25</b>	<b>FYCJS-25</b>	0.275	34
<b>FYCR-30</b>	<b>FYCRS-30</b>	0.48	51
<b>FYCJ-30</b>	<b>FYCJS-30</b>	0.47	51
<b>FYCR-35</b>	<b>FYCRS-35</b>	0.64	58
<b>FYCJ-35</b>	<b>FYCJS-35</b>	0.635	58
<b>FYCR-40</b>	<b>FYCRS-40</b>	0.88	66
<b>FYCJ-40</b>	<b>FYCJS-40</b>	0.865	66
<b>FYCR-45</b>	<b>FYCRS-45</b>	0.93	72
<b>FYCJ-45</b>	<b>FYCJS-45</b>	0.91	72
<b>FYCR-50</b>	<b>FYCRS-50</b>	0.995	76
<b>FYCJ-50</b>	<b>FYCJS-50</b>	0.965	76

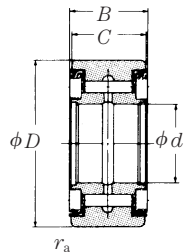
YCR (Full Complement)

YCRS (Full Complement, Sealed,  
With Thrust Washer)

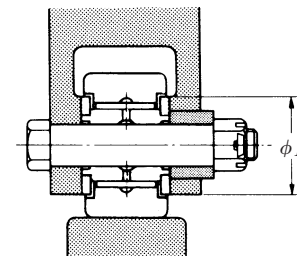
Bore Diameter 6.350 – 57.150 mm



YCR



YCRS



<i>d</i>	Boundary Dimensions (mm, inch)					Basic Load (N)		
	<i>D</i>	<i>C</i>	<i>B</i>	<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>			
<b>6.350</b>	0.2500	19.050	0.7500	12.70	0.5000	14.29	8 850	14 400
		22.225	0.8750	12.70	0.5000	14.29	8 850	14 400
<b>7.938</b>	0.3125	25.400	1.0000	15.88	0.6250	17.46	11 200	20 800
		28.575	1.1250	15.88	0.6250	17.46	11 200	20 800
<b>9.525</b>	0.3750	31.750	1.2500	19.05	0.7500	20.64	18 500	32 000
		34.925	1.3750	19.05	0.7500	20.64	18 500	32 000
<b>11.112</b>	0.4375	38.100	1.5000	22.22	0.8750	23.81	21 700	42 000
		41.275	1.6250	22.22	0.8750	23.81	21 700	42 000
<b>12.700</b>	0.5000	44.450	1.7500	25.40	1.0000	26.99	27 700	60 000
		47.625	1.8750	25.40	1.0000	26.99	27 700	60 000
<b>15.875</b>	0.6250	50.800	2.0000	31.75	1.2500	33.34	41 500	85 500
		57.150	2.2500	31.75	1.2500	33.34	41 500	85 500
<b>19.050</b>	0.7500	63.500	2.5000	38.10	1.5000	39.69	52 500	118 000
		69.850	2.7500	38.10	1.5000	39.69	52 500	118 000
<b>25.400</b>	1.0000	76.200	3.0000	44.45	1.7500	46.04	76 000	172 000
		82.550	3.2500	44.45	1.7500	46.04	76 000	172 000
<b>28.575</b>	1.1250	88.900	3.5000	50.80	2.0000	52.39	99 000	228 000
<b>31.750</b>	1.2500	101.600	4.0000	57.15	2.2500	58.74	126 000	285 000
<b>44.450</b>	1.7500	127.000	5.0000	69.85	2.7500	73.02	198 000	435 000
<b>57.150</b>	2.2500	152.400	6.0000	82.55	3.2500	85.72	283 000	645 000

Remarks Standard grease is packed in sealed cam followers, but not in cam followers without seals.

Ratings (kgf)		Bearing Numbers		Limiting Track Loads (N)		Mass (kg)	Shoulder Dimensions (mm)	Fillet Radius (mm)
<i>C<sub>r</sub></i>	<i>C<sub>or</sub></i>	YCR	YCRS	<i>F</i> <sub>min</sub>	<i>F</i> <sub>max</sub>	approx	<i>F</i> <sub>min</sub>	<i>r<sub>a</sub></i> <sub>max</sub>
900	1 470	<b>YCR-12</b>	<b>YCRS-12</b>	4 550	465	0.027	12.7	0.4
900	1 470	<b>YCR-14</b>	<b>YCRS-14</b>	5 150	525	0.036	12.7	0.4
1 140	2 120	<b>YCR-16</b>	<b>YCRS-16</b>	6 550	670	0.068	15.1	0.8
1 140	2 120	<b>YCR-18</b>	<b>YCRS-18</b>	7 450	760	0.077	15.1	0.8
1 890	3 250	<b>YCR-20</b>	<b>YCRS-20</b>	10 400	1 060	0.11	19.0	0.8
1 890	3 250	<b>YCR-22</b>	<b>YCRS-22</b>	11 500	1 170	0.135	19.0	0.8
2 220	4 250	<b>YCR-24</b>	<b>YCRS-24</b>	15 000	1 530	0.185	22.6	0.8
2 220	4 250	<b>YCR-26</b>	<b>YCRS-26</b>	16 300	1 660	0.225	22.6	0.8
2 830	6 150	<b>YCR-28</b>	<b>YCRS-28</b>	20 000	2 040	0.29	26.6	1.1
2 830	6 150	<b>YCR-30</b>	<b>YCRS-30</b>	21 500	2 190	0.365	26.6	1.1
4 250	8 750	<b>YCR-32</b>	<b>YCRS-32</b>	29 100	2 970	0.475	30.6	1.3
4 250	8 750	<b>YCR-36</b>	<b>YCRS-36</b>	33 000	3 350	0.60	30.6	1.3
5 350	12 000	<b>YCR-40</b>	<b>YCRS-40</b>	41 000	4 200	0.815	34.9	2.3
5 350	12 000	<b>YCR-44</b>	<b>YCRS-44</b>	45 500	4 650	1.0	34.9	2.3
7 750	17 600	<b>YCR-48</b>	<b>YCRS-48</b>	60 000	6 100	1.4	44.4	2.3
7 750	17 600	<b>YCR-52</b>	<b>YCRS-52</b>	64 500	6 600	1.65	44.4	2.3
10 100	23 300	<b>YCR-56</b>	<b>YCRS-56</b>	81 500	8 300	2.25	48.8	2.3
12 800	29 100	<b>YCR-64</b>	<b>YCRS-64</b>	107 000	10 900	3.2	57.9	2.3
20 200	44 500	<b>YCR-80</b>	<b>YCRS-80</b>	154 000	15 700	6.0	82.6	4.1
28 800	65 500	<b>YCR-96</b>	<b>YCRS-96</b>	226 000	23 000	9.95	99.2	4.1

## NEEDLE ROLLERS

Pages

Metric Design	Roller Diameter	1–5 mm .....	B200
Inch Design	Roller Diameter	0.792–6.350 mm .....	B207







NSK needle rollers are made of carefully selected degassed bearing steel and given a precise grinding finish after heat treatment. Provided with the following characteristics, they have a wide range of applications, including gears, small engines and universal joints:

- (1) Most economical when applied as a full complement bearing
- (2) Very high load capacity
- (3) Smaller mounting space
- (4) Rollers with special crowning

### Types

Needle rollers come in the types shown in **Table 1**.

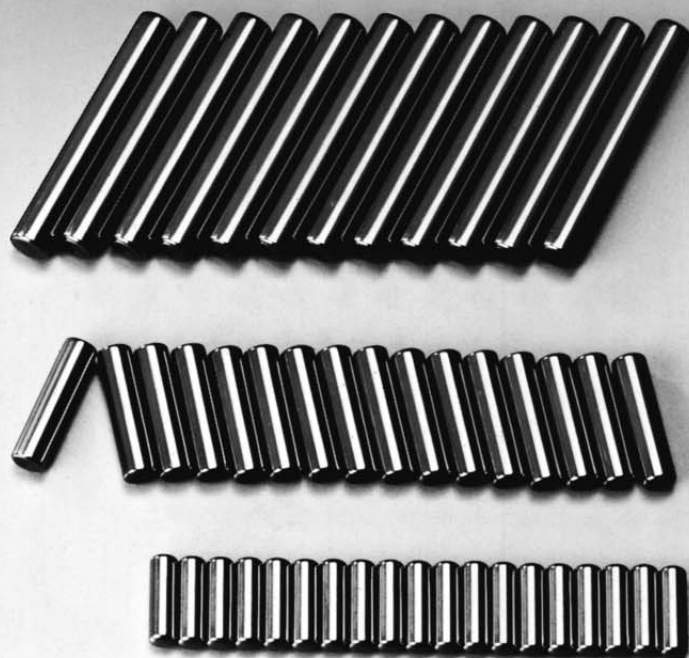
**Table 1 Needle Roller End Face Shapes and Codes**

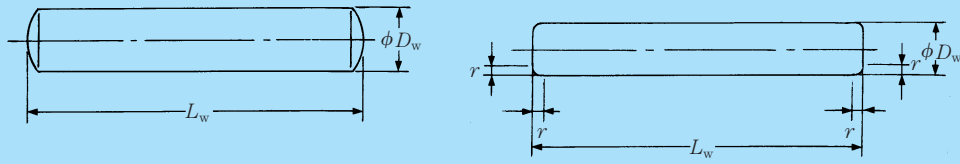
End Face Shape	Type	Code	Details
	Rounded	A	General
	Flat	F	General and large effective length
	Conical	T	Suitable for roller to be held in shaft or housing
	Trunnion	C	Suitable for roller to be held in shaft or housing
	Crank Pin	P	Suitable for large fillet radius, R, at the shoulder of mounting area
	Stepped	M	Suitable for roller to be held in shaft or housing

### Accuracy

NSK metric needle rollers are manufactured in compliance with ISO. Dimensions are shown in **Table 2** and dimension accuracy in **Table 3, 4** and **5**.

Inch needle rollers are manufactured with a standard diameter tolerance of 0 to  $-5\mu\text{m}$ . Needle rollers with a diameter tolerance of 0 to  $-3\mu\text{m}$  and 0 to  $-2\mu\text{m}$  are also available and manufactured upon request. Please consult NSK for further details.





**Table 2 Nominal Size and Dimension of Needle Rollers**

Units: mm

Units: mm

Nominal Size	$D_w$	$L_w$	$r^{(1)}$ (min)	Mass (kg) (Reference) per 1,000 pieces	Nominal Size	$D_w$	$L_w$	$r^{(1)}$ (min)	Mass (kg) (Reference) per 1,000 pieces
1 × 5.8	1	5.8	0.1	0.035	3.5 × 19.8	3.5	19.8	0.1	1.50
1 × 6.8	1	6.8	0.1	0.042	3.5 × 21.8	3.5	21.8	0.1	1.65
1 × 7.8	1	7.8	0.1	0.048	3.5 × 23.8	3.5	23.8	0.1	1.80
1 × 9.8	1	9.8	0.1	0.060	3.5 × 25.8	3.5	25.8	0.1	1.95
1.5 × 5.8	1.5	5.8	0.1	0.080	3.5 × 27.8	3.5	27.8	0.1	2.10
1.5 × 6.8	1.5	6.8	0.1	0.093	3.5 × 29.8	3.5	29.8	0.1	2.25
1.5 × 7.8	1.5	7.8	0.1	0.105	3.5 × 31.8	3.5	31.8	0.1	2.40
1.5 × 9.8	1.5	9.8	0.1	0.135	3.5 × 34.8	3.5	34.8	0.1	2.60
1.5 × 11.8	1.5	11.8	0.1	0.160	4 × 13.8	4	13.8	0.1	1.35
1.5 × 13.8	1.5	13.8	0.1	0.190	4 × 15.8	4	15.8	0.1	1.55
2 × 6.8	2	6.8	0.1	0.165	4 × 17.8	4	17.8	0.1	1.75
2 × 7.8	2	7.8	0.1	0.190	4 × 19.8	4	19.8	0.1	1.95
2 × 9.8	2	9.8	0.1	0.240	4 × 21.8	4	21.8	0.1	2.15
2 × 11.8	2	11.8	0.1	0.290	4 × 23.8	4	23.8	0.1	2.35
2 × 13.8	2	13.8	0.1	0.335	4 × 25.8	4	25.8	0.1	2.55
2 × 15.8	2	15.8	0.1	0.385	4 × 27.8	4	27.8	0.1	2.70
2 × 17.8	2	17.8	0.1	0.435	4 × 29.8	4	29.8	0.1	2.90
2 × 19.8	2	19.8	0.1	0.485	4 × 31.8	4	31.8	0.1	3.10
2.5 × 7.8	2.5	7.8	0.1	0.300	4 × 34.8	4	34.8	0.1	3.40
2.5 × 9.8	2.5	9.8	0.1	0.375	4 × 37.8	4	37.8	0.1	3.70
2.5 × 11.8	2.5	11.8	0.1	0.450	4 × 39.8	4	39.8	0.1	3.90
2.5 × 13.8	2.5	13.8	0.1	0.525	4.5 × 17.8	4.5	17.8	0.1	2.20
2.5 × 15.8	2.5	15.8	0.1	0.605	4.5 × 19.8	4.5	19.8	0.1	2.45
2.5 × 17.8	2.5	17.8	0.1	0.680	4.5 × 21.8	4.5	21.8	0.1	2.70
2.5 × 19.8	2.5	19.8	0.1	0.755	4.5 × 23.8	4.5	23.8	0.1	2.95
2.5 × 21.8	2.5	21.8	0.1	0.835	4.5 × 25.8	4.5	25.8	0.1	3.20
2.5 × 23.8	2.5	23.8	0.1	0.910	4.5 × 29.8	4.5	29.8	0.1	3.70
3 × 9.8	3	9.8	0.1	0.540	4.5 × 31.8	4.5	31.8	0.1	3.95
3 × 11.8	3	11.8	0.1	0.650	4.5 × 34.8	4.5	34.8	0.1	4.30
3 × 13.8	3	13.8	0.1	0.760	4.5 × 37.8	4.5	37.8	0.1	4.70
3 × 15.8	3	15.8	0.1	0.870	4.5 × 39.8	4.5	39.8	0.1	4.90
3 × 17.8	3	17.8	0.1	0.980	5 × 19.8	5	19.8	0.1	3.00
3 × 19.8	3	19.8	0.1	1.10	5 × 21.8	5	21.8	0.1	3.35
3 × 21.8	3	21.8	0.1	1.20	5 × 23.8	5	23.8	0.1	3.65
3 × 23.8	3	23.8	0.1	1.30	5 × 25.8	5	25.8	0.1	3.95
3 × 25.8	3	25.8	0.1	1.40	5 × 27.8	5	27.8	0.1	4.25
3 × 27.8	3	27.8	0.1	1.55	5 × 29.8	5	29.8	0.1	4.55
3 × 29.8	3	29.8	0.1	1.65	5 × 31.8	5	31.8	0.1	4.85
3.5 × 11.8	3.5	11.8	0.1	0.885	5 × 34.8	5	34.8	0.1	5.30
3.5 × 13.8	3.5	13.8	0.1	1.05	5 × 37.8	5	37.8	0.1	5.75
3.5 × 15.8	3.5	15.8	0.1	1.20	5 × 39.8	5	39.8	0.1	6.10
3.5 × 17.8	3.5	17.8	0.1	1.35	5 × 49.8	5	49.8	0.1	7.60

**Note** <sup>(1)</sup> Suitable for rollers with a flat end face.

**Remarks**  
 1. The figure shows the end faces with round and flat surfaces.  
 2. The minimum dimension and the maximum dimension of the fillet radius  $R$  of the end faces of the round surface are  $\frac{D_w}{2}$  and  $\frac{L_w}{2}$ , respectively.

**Table 3 Tolerances of Chamfer Dimension of Needle Rollers**

Units: mm

$D_w$		$r$ (min)	$r$ (max)
over	incl		
—	1	0.1	0.4
1	3	0.1	0.6
3	5	0.1	0.9

**Remarks** To be applied to the roller with a flat end face.

**Table 4 Tolerances of Dimension and Shape of Needle Rollers**

Units:  $\mu\text{m}$

Class	Mean Diameter Tolerance		Diameter Variation in Single Plane, <sup>(1)</sup>	Deformation, <sup>(1)</sup>	Variation Within Gauge Lot Diameter, <sup>(1)</sup>	Length Deviation, <sup>(2)</sup>
	high	low	$\Delta D_{WP}$	$\Delta R$	$VD_{WL}$	$\Delta L_{WS}$
			max	max	max	
2	0	-5	1	1	2	h13
3	0	-5	1.5	1.5	3	h13
5	0	-5	2	2.5	5	h13

**Notes** <sup>(1)</sup> To be applied at the center of a roller's length.

<sup>(2)</sup> According to  $L_w$  division. h13 is shown in **Table 5**.

**Remarks** For the overall length of the roller, any actual measured diameter shall not exceed the actual maximum diameter at the center of the length of the roller by more than the following values:  
 Class 2: 0.5  $\mu\text{m}$   
 Class 3: 0.8  $\mu\text{m}$   
 Class 5: 1  $\mu\text{m}$

**Table 5 Dimension Tolerance of Length**

Units: mm

Basic Design		h13	
over	incl	high	low
3	6	0	-0.18
6	10	0	-0.22
10	18	0	-0.27
18	30	0	-0.33
30	50	0	-0.39

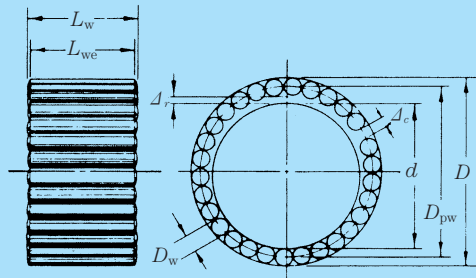


**Applications**

When a needle roller is applied as a full complement bearing, past performance generally demonstrates that the application of 35 rollers or less at a ratio of roller length,  $L_w$ , to roller diameter,  $D_w$ , of  $4 \leq L_w/D_w \leq 8$  produces good results. However, with combinations other than the above, many application results have been obtained. In general, good performance can be produced by applying fewer rollers with a larger roller diameter for normal rotation, and more rollers with smaller roller diameter for oscillation.

**Needle Roller Design Guidelines**

A standard needle roller is used as a full complement bearing. It is possible to easily obtain the approximate shaft diameter and housing bore diameter for each value of roller diameter and number of rollers from the graphs in **Fig. 1** to **Fig. 4** (B204 – B206). For detailed design, shaft diameter and housing bore diameter can be obtained in accordance with the design standard shown in **Table 6**. For these calculations, the recommended radial internal clearance,  $\Delta_r$ , and circumference clearance,  $\Delta_c$ , for each application condition are shown in **Table 7** and **Table 8** and the Kordal coefficient,  $K = 1/\sin(180^\circ/Z)$ , in **Table 9**. For each shaft and housing bore tolerance class, H6 and h5 are recommended.



**Table 6 Design Standards**

Code	Details	Calculation Equation
Z	Number of rollers	
K	Kordal coefficient	$K = 1/\sin \frac{180^\circ}{Z}$ (refer to Table 9)
$\Delta_c$	Circumference clearance (min)	According to Table 7 and Table 8
$\Delta_r$	Radial internal clearance (min)	According to Table 7 and Table 8
$D_{pw}$	Roller pitch diameter	$D_{pw} = KD_w + \Delta_c/\pi = D - D_w = d + \Delta_r + D_w$
D	Housing bore diameter (min)	$D = D_{pw} + D_w = (K+1)D_w + \Delta_c/\pi = d + \Delta_r + 2D_w$
d	Shaft diameter (max)	$d = D_{pw} - D_w - \Delta_r = (K-1)D_w + \Delta_c/\pi - \Delta_r = D - 2D_w - \Delta_r$
$D_w$	Roller diameter (max)	$D_w = D_{pw} - d - \Delta_r = \frac{D_{pw} - \Delta_c/\pi}{K} = \frac{d + \Delta_r - \Delta_c/\pi}{(K-1)} = D - D_{pw} = \frac{D - \Delta_c/\pi}{(K+1)}$
$L_{we}$	Roller effective length	In case of round surface roller, $L_{we} \doteq L_w - (\frac{D_w}{2} \sim \frac{D_w}{4})$
$L_w$	Roller length (max)	

**Table 7 Minimum Clearance under Normal Rotational Condition**

Units: mm

Nominal Shaft Diameter		Circumference Clearance, $\Delta_c$	Radial Internal Clearance, $\Delta_r$
over	incl		
	3	0.08	0.006
3	6	0.08	0.008
6	10	0.08	0.009
10	18	0.08	0.011
18	30	0.08	0.013
30	50	0.16	0.016
50	80	0.16	0.019
80	120	0.16	0.022

**Table 8 Minimum Clearance under Application Conditions**

Units: mm

Application Part	Circumference Clearance, $\Delta_c$	Radial Internal Clearance, $\Delta_r$
Universal Joint	Value in <b>Table 7</b>	(Value in <b>Table 7</b> ) $\times 1/2$
Pilot	Value in <b>Table 7</b>	(Value in <b>Table 7</b> ) $\times 3$
Counter Shaft	(Value in <b>Table 7</b> ) $\times 2$	(Value in <b>Table 7</b> ) $\times 2$
Planetary Gear	0.21	0.015

**Table 9 Value of K**

Z	K	Z	K	Z	K
6	2.00000	26	8.29623	46	14.65365
7	2.30477	27	8.61379	47	14.97171
8	2.61313	28	8.93141	48	15.28979
9	2.92380	29	9.24907	49	15.60788
10	3.23607	30	9.56677	50	15.92597
11	3.54947	31	9.88452	51	16.24408
12	3.86370	32	10.20230	52	16.56219
13	4.17858	33	10.52011	53	16.88031
14	4.49395	34	10.83795	54	17.19844
15	4.80973	35	11.15582	55	17.51657
16	5.12583	36	11.47371	56	17.83471
17	5.44219	37	11.79163	57	18.15286
18	5.75877	38	12.10957	58	18.47101
19	6.07553	39	12.42752	59	18.78916
20	6.39245	40	12.74550	60	19.10732
21	6.70951	41	13.06349		
22	7.02667	42	13.38149		
23	7.34394	43	13.69951		
24	7.66130	44	14.01754		
25	7.97873	45	14.33559		

**Assembly of Rollers by Keystone**

When it is necessary to hold the rollers with the keystone method during the process of installing them in the housing, whether or not the rollers are securely held can be checked by the following equation:

$$D_w (\text{min}) \times Y > D (\text{max})$$

where,

$D_w (\text{min})$  : Minimum roller diameter dimension

$D (\text{max})$  : Maximum housing bore dimension

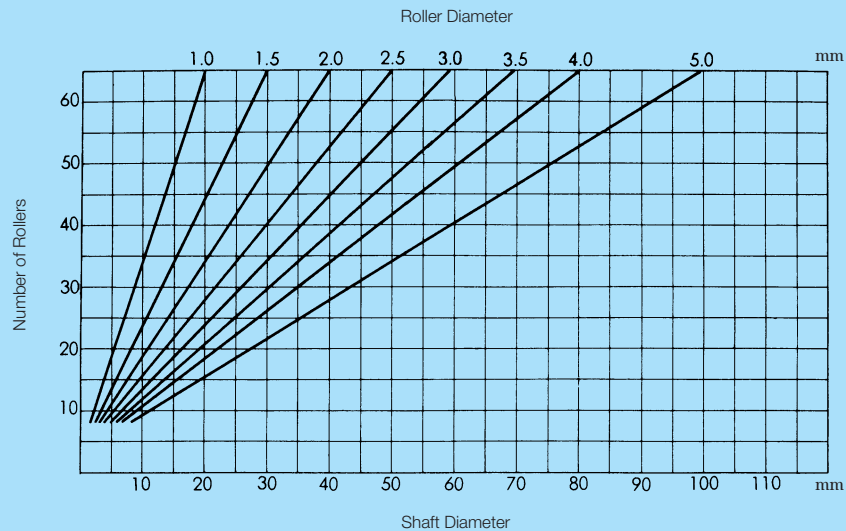
$Y$  : Keystone constant (refer to **Table 10**)

**Table 10 Keystone Constant**

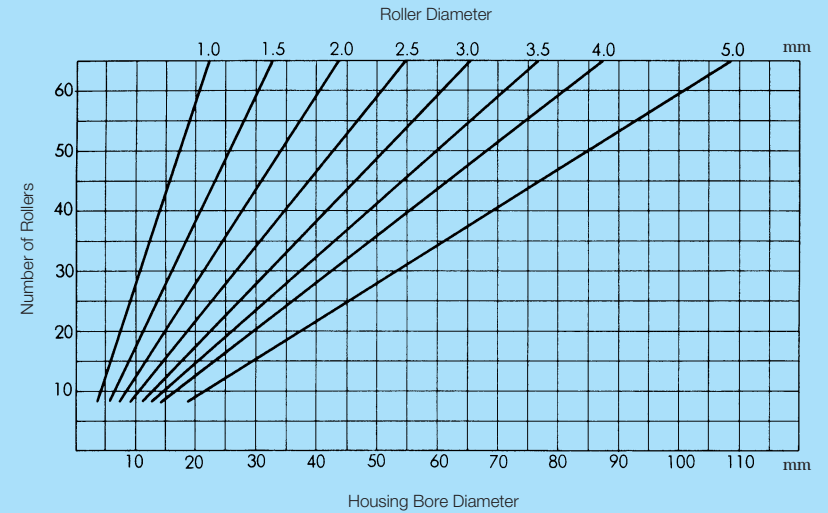
Z	K	Z	K
8	3.67633	17	6.45365
9	3.97094	18	6.76893
10	4.27277	19	7.08461
11	4.57895	20	7.40061
12	4.88797	21	7.71688
13	5.19892	22	8.03337
14	5.51128	23	8.35005
15	5.82467	24	8.66689
16	6.13885	25	8.98387

**Specifications of Shaft and Housing**

As needle rollers are applied directly to the shaft and housing bore, it is necessary to have the shaft and housing bore conform to uniform specifications. For these specifications, please refer to the section on cage and roller assemblies on page B7.



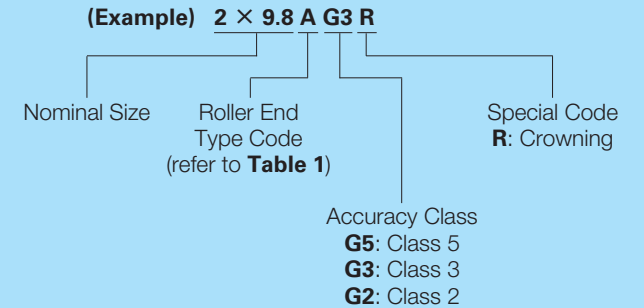
**Fig. 1 Roller Number and Shaft Diameter for Standard Metric Roller Diameter**



**Fig. 2 Number of Rollers and Housing Bore Diameter for Standard Metric Roller Diameter**

**Product Number of Rollers**

**Note** Product number is shown with nominal size, roller end type code, accuracy class, and special code, as necessary.



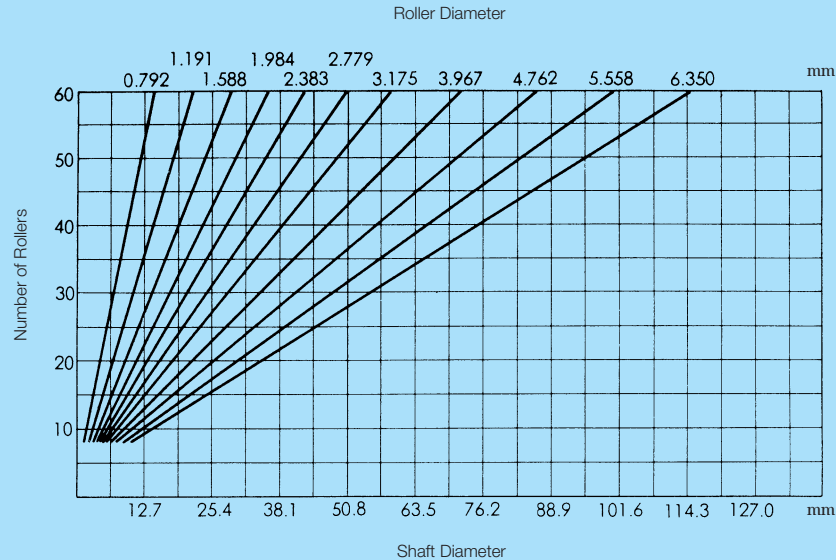


Fig. 3 Number of Rollers and Shaft Diameter for Standard Inch Roller Diameter

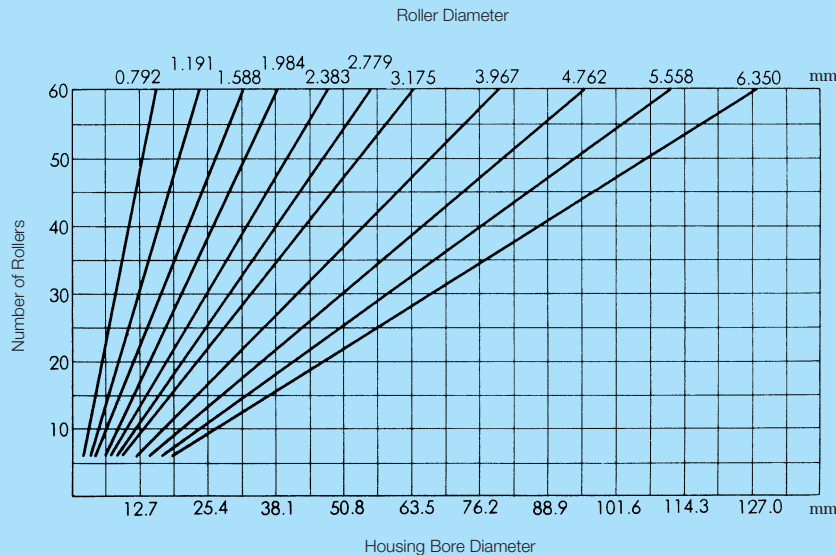


Fig. 4 Number of Rollers and Housing Bore Diameter for Standard Inch Roller Diameter

Table 11 Nominal Size and Dimension of Inch Needle Rollers

Specification (mm)		Product Number	Mass per 1,000 pieces, kg (approx)	Specification (mm)		Product Number	Mass per 1,000 pieces, kg (approx)
Diameter, $D_w$	Length, $L_w$			Diameter, $D_w$	Length, $L_w$		
0.792	3.05	Q-8266	0.012	3.175	12.70	M-484-Q	0.780
	4.06	Q-8267	0.016		14.22	Q-8304	0.875
	4.83	Q-8100	0.019		15.75	Q-8371	0.970
	5.59	Q-8268	0.021		19.05	C-407-Q	1.15
	6.35	Q-8101	0.024		22.35	Q-8122	1.40
	7.11	Q-8269	0.027		25.40	B-1316-Q	1.55
	7.87	Q-8102	0.030		28.45	Q-8123	1.75
1.191	4.06	Q-8271	0.035	31.75	Q-437-Q	1.95	
	4.83	Q-8272	0.042	35.05	Q-8310	2.15	
	5.59	Q-8273	0.048	3.967	15.75	Q-8254	1.50
	6.35	Q-8103	0.055		19.05	Q-8314	1.85
	7.11	Q-8274	0.062		22.35	Q-8315	2.15
	7.87	Q-8104	0.068		25.40	Q-8124	2.45
	9.65	Q-8105	0.084		28.45	Q-8316	2.75
11.18	Q-8106	0.097	31.75		E-151-Q	3.05	
1.588	6.35	Q-8276	0.098		35.05	Q-8317	3.35
	7.11	Q-8277	0.110	38.10	R-315-Q	3.65	
	7.87	S-1414-Q	0.120	4.762	19.05	Q-8320	2.66
	9.65	Q-8107	0.150		22.35	Q-8321	3.11
	11.18	Q-8108	0.170		25.40	Q-436-Q	3.55
	12.70	Q-1821	0.195		28.45	Q-8322	3.99
	14.22	Q-8109	0.220		31.75	G-529-Q	4.44
15.75	H-368-Q	0.245	35.05		Q-8323	4.88	
19.05	Q-8284	0.295	38.10		P-377-Q	5.33	
1.984	7.87	Q-8286	0.190	44.45	C-951-Q	6.11	
	9.65	Q-8287	0.230	5.558	22.35	Q-8328	4.20
	11.18	Q-8110	0.270		25.40	Q-8125	4.80
	12.70	Q-8111	0.305		28.45	Q-8329	5.35
	14.22	Q-8112	0.340		31.75	Q-8126	6.00
	15.75	Q-8049	0.380		35.05	Q-8330	6.60
	19.05	Q-8114	0.460		38.10	Q-8127	7.20
22.35	Q-8289	0.540	44.45		Q-8332	8.40	
2.283	9.65	Q-8290	0.335	50.80	Q-8334	9.60	
	11.18	Q-8291	0.390	6.350	25.40	C-435-Q	6.25
	12.70	Q-8292	0.440		28.45	Q-8336	7.00
	14.22	Q-8115	0.495		31.75	O-197-Q	7.80
	15.75	Q-8116	0.545		35.05	Q-8337	8.65
	19.05	H-230-Q	0.660		38.10	F-236-Q	9.40
	22.35	Q-8037	0.775		44.45	C-434-Q	11.0
25.40	Q-8294	0.880	50.80		W-430-Q	12.5	
2.779	11.18	Q-8296	0.530	57.15	G-613-Q	14.0	
	12.70	Q-8297	0.600	63.50	Q-8340	15.5	
	14.22	Q-8298	0.670	6.350	25.40	Q-8335	6.75
	15.75	Q-8118	0.745		28.45	Q-8338	7.40
	19.05	Q-8119	0.900		31.75	Q-8339	8.05
	22.35	Q-8120	1.05		35.05	Q-8341	8.70
	25.40	Q-8121	1.20		38.10	Q-8342	9.35
28.45	Q-8303	1.35	44.45		Q-8343	10.00	

**Remarks** 1. Rollers in the table are manufactured with the following tolerances :  
 Mean value of roller diameters: 0 to -0.005 mm  
 Roller length : 0 to -0.5 mm  
 2. All roller end faces in the table have a rounded end.  
 Please consult NSK for selection.

## SPHERICAL PLAIN BEARINGS

Pages

Metric Design	Bore Diameter	12–160 mm .....	B214–B217
Inch Design	Bore Diameter	12.700–152.400 mm .....	B218–B219

Spherical plain bearings are self-aligning. They are designed to carry heavy radial loads and combinations of radial and axial loads and to adjust the inclination of the inner ring and outer ring.

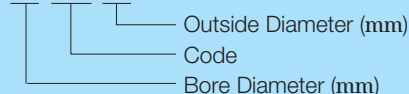
They are widely used in industrial and construction machinery and equipment that is characterized by low-speed oscillation and operation.

### Design and Types

The simple structure consists of an inner ring with a spherical outside surface of the same diameter mounted to a single or double-cut split outer ring with a ground, spherical bore surface. Both inner and outer rings are made of high-carbon chromium bearing steel, fully hardened to HRC55 or more, and given a precise grinding finish. All the surfaces of the inner and outer rings are given phosphate surface treatment and covered with a coating of molybdenum disulfide.

The bearing codes and the details are shown in **Table 1**. Bearing numbers are formulated as follows. (Please note that inch bearings have their own bearing number formula that differs from metric bearings.)

(Example) **20 FSF 32**



Although the bearing table shows FSF and SF bearings with single-cut outer ring, FSBB and SBB types with a double-cut split outer ring are also available.

Special spherical plain bearings, e.g., thrust spherical plain bearings, extended inner ring spherical plain bearings and spherical plain bearings made of special materials are also available. Please contact NSK for further details.

**Table 1 Bearing Types**

	Code	Details
Metric	FSF	Outer ring, single-cut
	FSFTT	Outer ring, single-cut with seal
	FSBB	Outer ring, double-cut split After the inner ring is mounted, it is fitted with a snap ring.
Inch	SF	Outer ring, single-cut
	SF ... TT	Outer ring, single-cut with seal
	SBB	Outer ring, double-cut split After the inner ring is mounted, it is fitted with a snap ring.



**Accuracy**

The dimensional tolerances of NSK's metric spherical plain bearings are in accordance with the accuracy of ISO of radial bearings (refer to pages A26 and A27). However, dimensional tolerance values are before surface treatment and outer ring splitting. For FSBB bearings, the dimensional tolerance of the inner ring bore diameter is the value after surface treatment.

The dimensional tolerances of Inch spherical plain bearings are shown in **Table 2.1** and **Table 2.2**.

**Table 2.1 Dimensional Tolerances of Inner Ring Bore Diameter and Width (Inch)**

Units:  $\mu\text{m}$

Nominal Bore Diameter, $d$ (mm)		Single Plane Mean Bore Diameter Deviation, $\Delta d_{mp}$ (1)		Deviation of a single inner ring with $\Delta B_s$	
over	incl	high	low	high	low
11.112 ( $7/16$ )	50.800 (2)	0	-13	0	-130
50.800 (2)	76.200 (3)	0	-20	0	-130
76.200 (3)	120.650 ( $4\ 3/4$ )	0	-20	0	-130
120.650 ( $4\ 3/4$ )	152.400 (6)	0	-25	0	-130

**Note** (1) Value after surface treatment

**Table 2.2 Dimensional Tolerances of Outer Ring Outside Diameter and Width (Inch)**

Units:  $\mu\text{m}$

Nominal Outside Diameter, $D$ (mm)		Single Plane Mean Outside Diameter Deviation, $\Delta D_{mp}$ (1)		Deviation of a single outer ring with $\Delta C_s$	
over	incl	high	low	high	low
20.638 ( $13/16$ )	50.800 (2)	0	-13	0	-130
50.800 (2)	80.962 ( $3\ 3/16$ )	0	-15	0	-130
80.962 ( $3\ 3/16$ )	120.650 ( $4\ 3/4$ )	0	-20	0	-130
120.650 ( $4\ 3/4$ )	177.800 (7)	0	-25	0	-130
177.800 (7)	222.250 ( $8\ 3/4$ )	0	-30	0	-130

**Note** (1) Value before surface treatment and outer ring splitting

**Applications**

**Dynamic Load Capacity ( $C_d$ )**

The dynamic load capacity shown in the Bearing Table indicates the maximum load that the bearing can carry under the following conditions:

1. Intermittent motion and load
2. Appropriate lubrication and periodic oiling
3. Appropriate fittings
4. Proper design of shaft and housing

In the case of continuous operation with the same load, however, the bearing load is required to be 75% of the dynamic load capacity or less.

For the permissible sliding speed of bearings, which depends on bearing load, lubrication, heat generation, sliding contact surface condition and other factors, the  $PV$  value is shown here as a guide:

$$PV \leq 24.5 \text{ (N/mm}^2 \cdot \text{m/min)}$$

$$PV \leq 2.5 \text{ (kgf/mm}^2 \cdot \text{m/min)}$$

where,

$P$  (N/mm<sup>2</sup>): Value obtained from the bearing load divided by the projected area of sliding surface

$V$  (m/min): Sliding speed

Special care is needed in lubrication, fitting and other areas in connection with such motion as high-frequency micro oscillation. Please consult NSK for further details.

**Maximum Permissible load ( $C_s$ )**

The maximum permissible load shown in the bearing table is the maximum static load that can be imposed on the bearing. If the load carried by the bearing is close to the maximum permissible load, the stress produced on the shaft or housing may reach its limit. Care should be taken accordingly.

**Radial Internal Clearance**

Depending on bearing dimensions, bearings are manufactured with radial internal clearance of between 0.09 mm to 0.27 mm before mounting.

**Permissible Misalignment**

Generally, the permissible misalignment of a spherical sliding bearing is limited by the bearing's surrounding structure. Shown in the bearing table is the angle that allows inclination without any reduction in the permissible load on a single spherical plain bearings.

**Fitting**

Recommended fittings for application of spherical plain bearings are shown in **Table 3**.

**Table 3 Recommended Fittings**

Load Condition	Fitting Tolerance	
	Shaft	Housing Bore
Light Load	m6	H7
Heavy Load	Metric bearing f6	N7
	Inch bearing g6	

**Design of Shaft and Housing**

**Shaft**

In general, because oscillating and rotating motion is generated between the shaft and inner ring bore surface as the load becomes larger, it is important to establish a standard shaft hardness and surface roughness. It is required, therefore, for the shaft to have a hardness of **HRC58** or more and a roughness of **0.8µmRa**. In addition, in order minimize shaft deflection, the support part of the shaft should be placed close to the inner ring.

With axial loads, the shoulder of the shaft in contact with the side face of the inner ring, which serves to support the load, requires sufficient strength and hardness. When rotating or oscillating motion is involved, the surface in contact with the side face of the inner ring should be finished to a roughness of **0.8µmRa**.

**Housing**

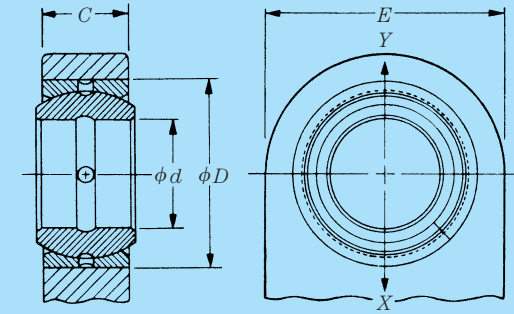
The housing should be rigid enough to avoid deformation caused by external load.

The critical points of design when using the housing shape shown **Fig. 1** are as follows. In case the external load works in the **X** direction, the compressive strength of the housing materials should be greater than the value of the load divided by the bearing projected area ( $C \times D$ ).

When the external load works in the **Y** direction, the tensile strength of the housing should be greater than the value of the imposed load multiplied by  $\frac{K}{C(E-D)}$ . The values of coefficient **K** are shown in **Table. 4**.

**Table 4 Values of Coefficient K**

E/D	K	E/D	K	E/D	K
1.2	1.8	1.8	2.4	3.0	3.7
1.4	2.0	2.0	2.7	4.0	4.7
1.6	2.2	2.5	3.2	5.0	5.5



**Fig. 1**

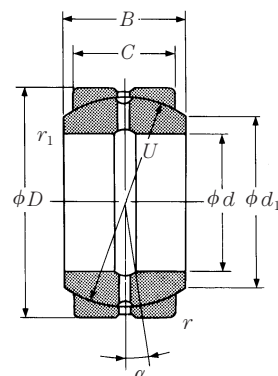
**Lubrication**

The inner and outer rings are provided with an oil groove and oil hole. Lubricant should be supplied to the fitting and spherical surface of the shaft through either the shaft or housing. The lubrication interval varies depending on conditions such as magnitude of load, oscillating speed, oscillating angle, ambient condition and sealing condition.

As the load capacity of the bearing is determined by the oil film strength of the lubricant to be used, selection of lubricant is important. In general, a lubricant containing extreme pressure additives is recommended.

FSF

Bore Diameter 12 — 65 mm

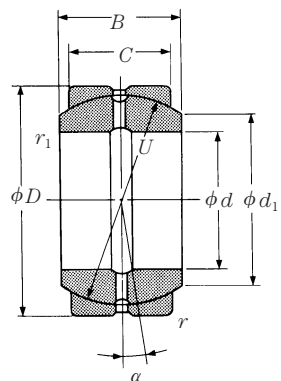


d	Boundary Dimensions (mm)						Load Capacities			
	D	C	B	r min	r1 min	U	Dynamic Loads (N)		Limiting Loads (N)	
							Cd		Cs	
12	22	7	10	0.3	0.3	18	7 350	750	31 000	3 150
	22	9	11	0.3	0.3	18	7 550	770	37 000	3 750
15	26	9	12	0.3	0.3	22	11 700	1 200	46 500	4 750
	26	11	13	0.3	0.3	22	12 600	1 290	54 000	5 500
17	30	10	14	0.3	0.3	25	16 200	1 650	56 500	5 750
20	32	14	16	0.3	0.3	28	21 100	2 150	89 000	9 050
	35	12	16	0.3	0.3	29	21 900	2 240	73 500	7 500
22	37	16	19	0.3	0.3	32	28 800	2 930	114 000	11 600
25	42	16	20	0.3	0.3	35.5	35 000	3 550	114 000	11 700
	42	18	21	0.3	0.3	36	37 500	3 800	133 000	13 500
30	47	18	22	0.3	0.3	40.7	47 500	4 850	156 000	15 900
	50	23	27	0.6	0.6	45	57 500	5 850	224 000	22 800
35	55	20	25	0.6	0.3	47	64 500	6 550	199 000	20 200
	55	26	30	0.6	0.6	50	73 500	7 500	286 000	29 100
40	62	22	28	0.6	0.3	53	83 500	8 550	243 000	24 800
	62	28	33	0.6	0.6	55	95 500	9 750	325 000	33 500
45	68	25	32	0.6	0.3	60	106 000	10 800	330 000	34 000
	72	31	36	0.6	0.6	62	116 000	11 800	385 000	39 500
50	75	28	35	0.6	0.3	66	129 000	13 100	400 000	41 000
	80	36	42	0.6	0.6	72	151 000	15 400	565 000	57 500
55	90	40	47	0.6	0.6	80	185 000	18 900	670 000	68 000
60	90	36	44	1	0.3	80	197 000	20 100	615 000	62 500
	100	45	53	0.6	0.6	90	229 000	23 400	875 000	89 000
65	105	47	55	0.6	0.6	94	259 000	26 400	940 000	96 000

Bearing Numbers	Limiting Inclination Angles (°) α	Mass (kg) approx	Inner Ring Side Face Diameters (mm) d1 approx
12FSF22 12FSF22-1	11.5	0.017	14.9
	8.5	0.019	14.2
15FSF26 15FSF26-1	9.5	0.032	18.4
	7	0.035	17.7
17FSF30	11	0.049	20.7
20FSF32 20FSF35	5.5	0.053	22.9
	9.5	0.065	24.1
22FSF37	7	0.085	25.7
25FSF42 25FSF42-1	8	0.11	29.3
	6	0.13	29.2
30FSF47 30FSF50	7	0.155	34.2
	6.5	0.235	36
35FSF55 35FSF55-1	7.5	0.235	39.7
	6	0.305	40
40FSF62 40FSF62-1	7.5	0.33	45
	6.5	0.395	44
45FSF68 45FSF72	8	0.43	50.7
	6	0.615	50.4
50FSF75 50FSF80	7	0.575	55.9
	6	0.90	58.4
55FSF90	6	1.25	64.7
60FSF90 60FSF100	7	1.1	66.8
	6.5	1.7	72.7
65FSF105	6	2.05	76

FSF

Bore Diameter 70 — 160 mm



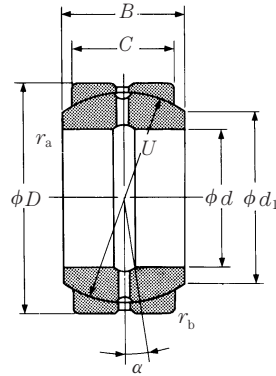
d	Boundary Dimensions (mm)						Load Capacities			
	D	C	B	r <sub>min</sub>	r <sub>1 min</sub>	U	Dynamic Loads (N)		Limiting Loads (N)	
							C <sub>d</sub>		C <sub>s</sub>	
70	105	40	49	1	0.3	92	256 000	26 100	775 000	79 500
	110	50	58	0.6	0.6	100	293 000	29 800	1 110 000	113 000
75	120	55	64	0.6	0.6	110	345 000	35 500	1 380 000	140 000
80	120	45	55	1	0.3	105	330 000	33 500	1 000 000	102 000
	130	60	70	0.6	0.6	120	410 000	42 000	1 660 000	169 000
85	135	63	74	0.6	0.6	125	455 000	46 500	1 810 000	185 000
90	130	50	60	1.1	1	115	385 000	39 000	1 220 000	125 000
	140	65	76	0.6	0.6	130	500 000	51 000	1 970 000	201 000
95	150	70	82	0.6	0.6	140	575 000	58 500	2 260 000	230 000
100	150	55	70	1.1	1	130	510 000	52 000	1 460 000	149 000
	160	75	88	1	1	150	640 000	65 500	2 580 000	263 000
110	160	55	70	1.1	1	140	560 000	57 000	1 660 000	169 000
	170	80	93	1	1	160	750 000	76 000	2 980 000	305 000
115	180	85	98	1	1	165	815 000	83 500	2 880 000	294 000
120	180	70	85	1.1	1	155	745 000	76 000	1 970 000	201 000
	190	90	105	1	1	175	925 000	94 500	3 250 000	330 000
130	200	95	110	1	1	185	1 040 000	106 000	3 600 000	370 000
140	210	70	90	2	1	180	920 000	94 000	2 610 000	266 000
150	220	105	120	1	1	205	1 330 000	136 000	4 300 000	440 000
160	230	80	105	2	1	200	1 250 000	128 000	3 250 000	330 000

Bearing Numbers	Limiting Inclination Angles (°) α	Mass (kg) approx	Inner Ring Side Face Diameters (mm) d <sub>1</sub> approx
70FSF105	6.5	1.55	78
70FSF110	5.5	2.2	81
75FSF120	5.5	3.0	89
80FSF120	6.5	2.3	89
80FSF130	6	4.0	97
85FSF135	6	4.25	101
90FSF130	6	2.7	98
90FSF140	6	4.7	105
95FSF150	6	6.05	113
100FSF150	7.5	4.4	110
100FSF160	6	7.4	121
110FSF160	7	4.8	121
110FSF170	5.5	8.55	130
115FSF180	5.5	10.5	133
120FSF180	6.5	7.8	130
120FSF190	6	12.5	140
130FSF200	5.5	14	149
140FSF210	7	11	156
150FSF220	5	17	166
160FSF230	8	14	170



SF

Bore Diameter 12.700 — 152.400 mm



<i>d</i>	Boundary Dimensions (mm, inch)					Load Dynamic Loads (N) {kgf}		
	<i>D</i>	<i>C</i>	<i>B</i>	<i>U</i>	<i>C<sub>d</sub></i>			
<b>12.700</b>	0.5000	22.225	0.8750	9.52	11.10	18.26	12 000	1 220
<b>15.875</b>	0.6250	26.988	1.0625	11.91	13.89	22.83	18 700	1 910
<b>19.050</b>	0.7500	31.750	1.2500	14.27	16.66	27.43	27 000	2 750
<b>22.225</b>	0.8750	36.512	1.4375	16.66	19.43	31.95	36 500	3 750
<b>25.400</b>	1.0000	41.275	1.6250	19.05	22.22	36.50	48 000	4 900
<b>31.750</b>	1.2500	50.800	2.0000	23.80	27.76	45.59	74 500	7 600
<b>34.925</b>	1.3750	55.562	2.1875	26.19	30.15	49.20	89 500	9 100
<b>38.100</b>	1.5000	61.912	2.4375	28.58	33.32	54.74	108 000	11 000
<b>44.450</b>	1.7500	71.438	2.8125	33.32	38.89	63.88	147 000	15 000
<b>50.800</b>	2.0000	80.962	3.1875	38.10	44.45	73.02	192 000	19 600
<b>57.150</b>	2.2500	90.488	3.5625	42.85	50.01	82.17	243 000	24 800
<b>63.500</b>	2.5000	100.012	3.9375	47.62	55.55	91.19	300 000	30 500
<b>69.850</b>	2.7500	111.125	4.3750	52.37	61.11	100.33	365 000	37 000
<b>76.200</b>	3.0000	120.650	4.7500	57.15	66.68	109.52	430 000	44 000
<b>82.550</b>	3.2500	130.175	5.1250	61.90	72.24	118.74	505 000	51 500
<b>88.900</b>	3.5000	139.700	5.5000	66.68	77.77	128.02	585 000	60 000
<b>95.250</b>	3.7500	149.225	5.8750	71.42	83.34	136.91	675 000	69 000
<b>101.600</b>	4.0000	158.750	6.2500	76.20	88.90	146.05	770 000	78 500
<b>107.950</b>	4.2500	168.275	6.6250	80.95	94.46	155.58	865 000	88 500
<b>114.300</b>	4.5000	177.800	7.0000	85.72	100.00	164.46	970 000	99 000
<b>120.650</b>	4.7500	187.325	7.3750	90.47	105.56	173.36	1 080 000	110 000
<b>127.000</b>	5.0000	196.850	7.7500	95.25	111.12	182.63	1 200 000	122 000
<b>152.400</b>	6.0000	222.250	8.7500	104.78	120.65	207.16	1 560 000	159 000

Capacities Limiting Loads (N) {kgf}		Bearing Numbers	Limiting Inclination Angles (°) <i>α</i>	Mass (kg) approx	Inner Ring Side Face Diameters (mm) <i>d</i> <sub>1</sub> approx	Fillet Radii (mm)	
<i>C<sub>s</sub></i>						Shaft <sup>(1)</sup> <i>r<sub>a</sub></i> max	Housing <sup>(1)</sup> <i>r<sub>b</sub></i> max
37 000	3 800	<b>5SF8</b>	7	0.020	14.3	—	0.6
58 000	5 900	<b>6SF10</b>	6.5	0.036	17.8	—	0.8
83 000	8 500	<b>7SF12</b>	6.5	0.057	21.4	—	0.8
113 000	11 600	<b>8SF14</b>	6.5	0.088	25.0	—	0.8
148 000	15 100	<b>10SF16</b>	6.5	0.125	28.6	—	0.8
231 000	23 600	<b>12SF20</b>	6.5	0.235	35.7	—	0.8
273 000	27 800	<b>13SF22</b>	6	0.35	38.9	—	0.8
335 000	34 000	<b>15SF24</b>	6.5	0.425	43.3	—	0.8
455 000	46 500	<b>17SF28</b>	6.5	0.65	50.0	—	0.8
590 000	60 500	<b>20SF32</b>	6.5	0.94	57.2	—	0.8
750 000	76 500	<b>22SF36</b>	6.5	1.3	65.1	—	0.8
925 000	94 500	<b>25SF40</b>	6.5	1.85	72.2	—	0.8
1 200 000	114 000	<b>27SF44</b>	6.5	2.45	79.4	0.6	0.8
1 330 000	136 000	<b>30SF48</b>	6	3.1	86.5	0.6	0.8
1 570 000	160 000	<b>32SF52</b>	6	3.9	94.1	0.6	0.8
1 820 000	186 000	<b>35SF56</b>	6	4.85	100.8	0.6	0.8
2 080 000	212 000	<b>37SF60</b>	6	5.9	108.0	0.6	0.8
2 370 000	242 000	<b>40SF64</b>	6	7.1	115.8	0.6	0.8
2 680 000	274 000	<b>42SF68</b>	6	8.45	122.9	0.8	1.1
2 990 000	305 000	<b>45SF72</b>	6	9.95	130.0	0.8	1.1
3 350 000	340 000	<b>47SF76</b>	6	11.5	137.4	0.8	1.1
3 700 000	380 000	<b>50SF80</b>	6	13.5	144.5	0.8	1.1
4 650 000	475 000	<b>60SF96</b>	5.5	17.5	167.4	0.8	1.1

Note (1) For bearings 5SF8 through 25SF40 inclusive, the shaft is undercut so there is no fillet radius *r<sub>a</sub>*.

## NEEDLE ROLLER BEARINGS FOR UNIVERSAL JOINTS

			Pages
Drawn Cup Type	Inscribed Circle Diameter	10–21.3 mm .....	B224–B225
Solid Type	Inscribed Circle Diameter	12.170–32.600 mm .....	B226–B227

Needle roller bearings for universal joints are available as drawn cup and solid. The drawn cup needle bearing has a large load capacity in spite of its small cross-sectional height. Since the material for the drawn cup (outer ring) is a special alloy steel sheet developed by the bearing performs well regarding fatigue and shock resistance. If this drawn cup needle bearing is applied, an economical universal joint with a large torque capacity can be designed.

A method for fixing a drawn cup needle bearing to the yoke hole is the tightening method (staking method). In some cases, the method of fixation with a rose washer is adopted. In any case, mounting is carried out using dedicated assembly equipment.

As the universal joint uses solid needle bearings in many cases and has demonstrated a high shock resistance, the bearing is particularly well-suited for use in universal joints in medium and large trucks.



## Types

Needle rolling bearings for universal joints are available in the types in **Table 1**.

**Table 1 Bearing Types**

Code	Details
ZY	Closed end drawn cup needle bearing that is fixed to the yoke by tightening or with a rose washer.
NSA	Closed end solid needle bearing that is fixed to the yoke with a snap ring or a detent plate. The outer ring has a sealing structure that varies depending on the fixation method.

### Drawn Cup Needle Roller Bearings for Universal Joints

These bearings are assembled into universal joints with their own dedicated assembly equipment.

Universal joints have the following characteristics:

- (1) It is possible to give a light preload between the joint spider end face and the bearing bottom.
- (2) It is possible to align the joint spider rotating center with the shaft rotating center as necessary.
- (3) Smaller size, lighter weight and working energy efficiency contribute to a reduced cost.

### Fitting

For each fitting tolerance of the joint spider and yoke hole, k6 and F7 are recommended respectively.

### Accuracy, Roughness and Hardness of the Joint Spider and Yoke Hole

Drawn cup needle bearings form a correct raceway track for the needle rollers only after press fitting into a yoke hole of specified dimensions. It is therefore necessary to finish the yoke hole accurately according to the dimensions specified. Accuracy, roughness and hardness of the joint spider and yoke hole are the same as standard drawn cup needle bearings (please refer to page B39). However, yoke hardness is required to be HRC23 to 28.

### Solid Needle Roller Bearings for Universal Joints

These bearings have proven past performance and are fixed to the yoke hole with a snap ring or detent plate. Because they are solid with a thick-wall outer ring, the bearing is well-suited for use in universal joints in medium and large vehicles on which a heavy load is imposed.

### Accuracy

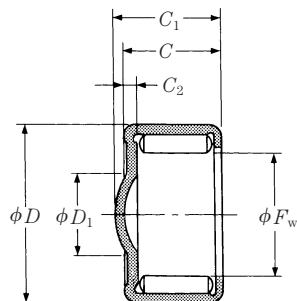
The dimensional tolerance of each part varies depending on each bearing. Please consult NSK for details.

### Fitting

As for the fittings between the bearing outside diameter and yoke hole, a transient or tight fit is commonly applied and the shaft diameter should be determined so that the radial minimum internal clearance is maintained at about 0.005 mm. For each bearing number, please consult NSK.

ZY

Inscribed Circle Diameter 10 — 21.3 mm

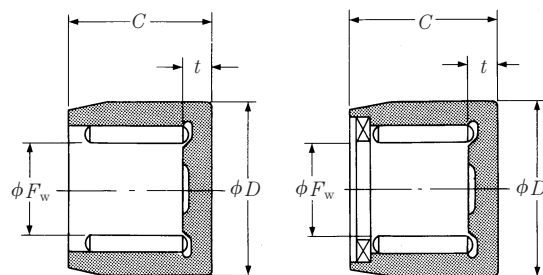


$F_w$	Boundary Dimensions (mm)					Basic Dynamic Load Ratings		Limiting Loads	
	$D$	$C$	$C_1$	$C_2$	$D_1$	(N)	{kgf}	(N)	{kgf}
<b>10</b>	16	8.95	10.15	1.30	11	6 600	675	3 750	380
	15	9.35	9.35	1.75	6	5 850	600	3 900	395
<b>12</b>	18	9.95	10.50	1.30	7.5	8 300	845	5 350	550
<b>14</b>	20	11.85	12.09	2.25	8.1	9 850	1 000	6 800	695
<b>16</b>	22	12.97	13.35	2.37	8	11 900	1 210	8 850	900
<b>18</b>	24	13.85	14.35	2.25	9.68	13 400	1 370	10 600	1 080
<b>21.3</b>	29	15.80	15.80	3.00	10.68	17 900	1 820	14 000	1 430

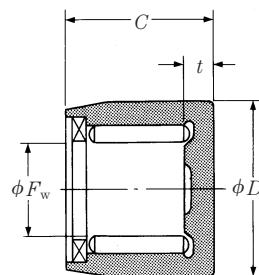
Bearing Numbers	Mass (g)	Ring Gage Dimensions (mm)	Plug Gage Dimensions (mm)	
	approx		Go End	No-Go End
<b>ZY-108</b>	6.9	16.016	10.014	10.036
<b>ZY-109</b>	6.6	15.016	10.011	10.026
<b>ZY-1210</b>	10	18.020	12.073	12.095
<b>ZY-1411</b>	12	20.020	14.009	14.035
<b>ZY-1612</b>	14	22.020	16.009	16.035
<b>ZY-1813</b>	17	24.620	18.009	18.035
<b>ZY-2115</b>	37	29.002	21.316	21.337

NSA

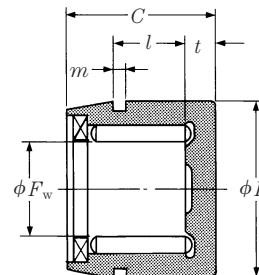
Inscribed Circle Diameter 12.170 — 32.600 mm



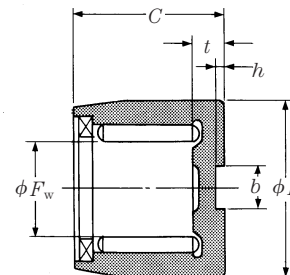
Example 1



Example 2



Example 3



Example 4

Boundary Dimensions (mm)			Dimensions (mm)					Basic Load (N)	
$F_w$	$D$	$C$	$t$	$l$	$m$	$b$	$h$	$C_r$	$C_{or}$
<b>12.170</b>	20.5	16	2	—	—	—	—	11 800	18 400
<b>14.270</b>	26	16	4	—	—	—	—	12 200	17 400
<b>14.724</b>	23.813	15	2	—	—	—	—	13 400	20 000
<b>14.800</b>	25	16.8	3.3	8.5	2.5	—	—	11 200	18 200
<b>17.000</b>	29	17.5	3.5	9.5	2	—	—	16 900	24 900
<b>17.780</b>	28	18.5	3.5	10	2	—	—	14 600	27 100
<b>18.460</b>	29	17.5	3.5	9.5	2	—	—	14 900	28 000
<b>21.941</b>	33	21.2	4	—	—	—	—	21 400	38 500
<b>23.020</b>	35	23	4	—	—	—	—	23 800	47 000
<b>26.995</b>	40	25.5	4	—	—	—	—	28 600	62 500
<b>28.600</b>	42	30	6	—	—	18	2	35 500	73 500
<b>30.517</b>	46	31.5	7	—	—	25	3	38 000	83 500
<b>32.600</b>	48	33.2	6	—	—	24	2	43 500	89 500

Ratings (kgf)		Bearing Numbers	Example	Mass (g) approx
$C_r$	$C_{or}$			
1 200	1 870	<b>NSA02001</b>	2	24
1 240	1 770	<b>NSA02601</b>	2	40
1 360	2 040	<b>NSA02424</b>	1	28
1 140	1 860	<b>NSA024A</b>	3	38
1 730	2 530	<b>NSA02901</b>	3	54
1 490	2 760	<b>NSA02803</b>	3	49
1 520	2 860	<b>NSA02903</b>	3	54
2 180	3 950	<b>NSA03301</b>	2	80
2 430	4 800	<b>NSA03501</b>	2	90
2 920	6 400	<b>NSA04002</b>	2	135
3 600	7 500	<b>NSA04204</b>	4	165
3 900	8 500	<b>NSA04604</b>	4	205
4 450	9 100	<b>NSA04803</b>	4	225

## DRAWN CUP ROLLER CLUTCHES

Pages

FC, FLC, RC	Shaft Diameter	4-30 mm .....	B234-B235
FCB, FCBN, RCB	Shaft Diameter	4-30 mm .....	B236-B237

Drawn cup roller clutches are very compact one-way clutches with a unique drawn cup outer ring. In spite of their lightweight and small section height, torque capacity is high. Operation is accurate and the friction torque when overrunning is small. Mounting is as easy as drawn cup needle bearings.

### Design and Types

Drawn cup roller clutches are composed of an outer ring, which forms the cam face on the drawn cup bore surface by precise deep drawing, as well as rollers, a cage and a spring.

The types of drawn cup roller clutches are shown in **Table 1** and the states of engagement and overruns are shown in **Fig. 1** and **Fig. 2**.

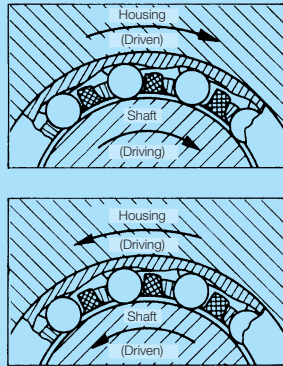
The metric FCP series for low-torque transmissions and plastic housings are available. Please consult NSK for further details.

**Table 1 Types of Drawn Cup Roller Clutches**

Type	Code	Details
Metric	FC	For torque transmissions only, containing stainless steel spring
	FCL	For torque transmissions only, containing stainless steel spring
	FCB	For torque transmissions and imposing of radial load, containing stainless steel spring
	FCBN	Narrow width type. For torque transmission and imposing of radial load, containing stainless steel spring
Inch	RC	For torque transmission only, containing plastic spring
	RCB	For torque transmission and imposing of radial load, containing plastic spring
	RC-FS	For torque transmission only, containing a stainless steel spring
	RCB-FS	For torque transmission and imposing of radial load, and containing a stainless steel spring

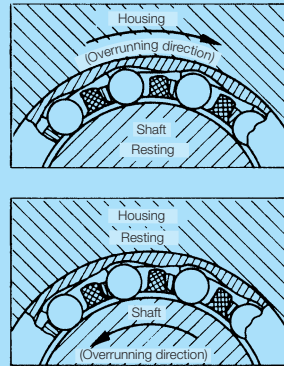
**Remarks** Drawn cup metric roller clutches have a standard structure of a spring pushing multiple rollers. In addition, the K type with a structure of a spring pushing a single roller is available for low torque (K is attached to the end of the product number).





**Fig. 1 Clutch in Engagement**

With the force of the spring mounted inside the clutch produced by the relative rotation of the clutch and the shaft mounted to the housing, the roller contacts the wedge face and engages it. The engagement directions are opposite depending on whether the shaft or housing is driven.



**Fig. 2 Clutch Overrun**

By the relative rotation of the clutch and the shaft mounted to housing, the roller operates free from the wedge face and overruns. In this case, the housing and the clutch overrun in a clockwise direction and the shaft overruns in a counterclockwise direction.

## Applications

### Specifications of Shaft and Housing

#### (1) Accuracy, Roughness and Hardness

Drawn cup roller clutches do not usually use an inner ring but use the shaft as the raceway ring. Made of a thin steel plate, they perform best only with press fitting into a normal housing. Therefore, the dimensional accuracy and hardness of the shaft and housing are required to satisfy the specifications shown below (Table 2).

**Table 2 Accuracy, Roughness and Hardness**

Item	Shaft	Housing
Out-of-Roundness Tolerance	$\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Cylindrical Tolerance	$\frac{IT3}{2}$	$\frac{IT4}{2}$ to $\frac{IT5}{2}$
Roughness, Ra	0.4	1.6
Hardness	HRC58 to 64	—

**Note** Please refer to Section 5.2 on page A34 and Section 5.3 on page A35 for further details.

#### (2) Housing Rigidity

In order to obtain the best performance from drawn cup roller clutches, the housing must have sufficient thickness and be designed to avoid deformation even if torque and radial loads are imposed. Special attention should be paid material quality and wall thickness of the housing. Housing material usually consists of steel. However, if cast iron housing is used, the maximum load torque value must not exceed 70% of torque capacity. For aluminum housing, the same value must not exceed 50% of torque capacity.

Even with steel housings, the outside diameter should be larger than the minimum outside diameter dimension of the housing shown in the bearing table.

#### Fitting

Drawn cup roller clutches can perform as designed only when used with standard fittings. Therefore, the shaft and housing bore should be finished to the recommended fitting dimensions shown in Table 3. The recommended values shown in Table 3 are for steel, provided that the housing outer diameter is larger than the minimum dimension shown in the bearing table.

Depending on application conditions, a fitting change may be required.

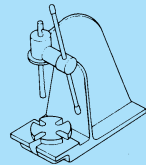
**Table 3 Fittings for Drawn Cup Roller Clutches**

Type		Fitting Tolerance	
		Shaft	Housing Bore
Metric	FC, FCL FCB, FCBN	h6	N7
Inch	RC (FS) RCB (FS)	h6	J7

### Mounting

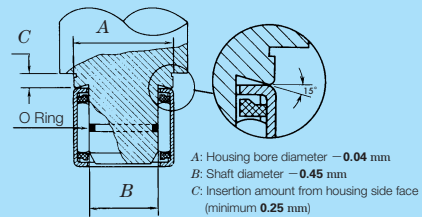
For press fitting of drawn cup roller clutches into the housing bore, it is necessary to prevent the outer ring from deformation and damage by using an appropriate jig as shown **Fig. 4**. Precautions for mounting are described below:

- (1) Use a hand press or similar for press fitting. Avoid applying blows with a hammer or similar instrument. (**Fig. 3**)



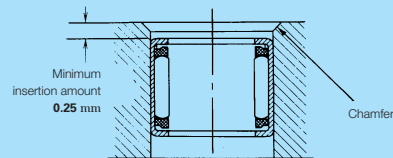
**Fig. 3**

- (2) Place the roller clutch side face on the marked side onto the jig shoulder. For accurate press fitting, provide a stopper for the locations and guide. (**Fig. 4**)



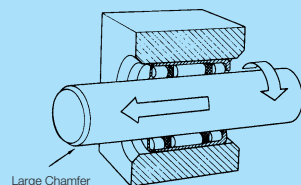
**Fig. 4**

- (3) A snap ring and shoulder for positioning the roller clutch are not required. When press fitting the roller clutch into the housing with a shoulder or a closed end, care should be taken not to have the side face of the roller clutch contact the shoulder or the bottom. (**Fig. 5**)



**Fig. 5**

- (4) When assembling the shaft, keep rotating it while mounting. A large chamfer for the corner of the shaft is advisable. (**Fig. 6**)



**Fig. 6**



**Fig. 7**

### Operating Temperature and Engagement Speed

The operating temperature of drawn cup roller clutches should be 90°C or less for a standard plastic spring and 120°C or less for a stainless steel spring.

When engagement speed exceeds 200 cycles per minute and when operation of the spring is impaired by low temperatures, a clutch with a stainless steel spring must be applied.

### Lubrication

Oil lubrication is generally recommended and, in the conditions described below, it is required.

- Overrunning
- High engagement speed
- Very low transmitting torque
- High operating temperature

As grease lubrication is common, NSK produces bearings packed with standard grease.

Grease containing extreme pressure additives should be avoided as it may cause slippage.

Hardening of grease due to deterioration and formation of sludge impair the lock performance of the clutch. Extreme caution must be taken for deterioration of lubricant.

Please consult NSK regarding the lubricant to be applied.

### Engagement Direction

Clutch engagement takes place when rotating the housing in the direction of the arrow (←LOCK) marked on the side face of the drawn cup outer ring. (Refer to **Fig. 7**)

### Cautions in Application

Some machines using a one-way clutch generate inertia during operation. In such cases, it is necessary to accurately determine the load torque imposed on the clutch.

In some cases, the torque actually imposed on the clutch is a far greater value than the value calculated based on the power source such as a motor or brake. Sometimes the transient response at the instant the clutch is locked, in particular, is this excessive load torque. (This is caused by the inertia force of the whole motion system surrounding the mounted clutch and therefore can hardly be calculated beforehand.)

If such a case is anticipated, it is necessary to select a clutch after measuring the impact value and correctly grasping the torque imposed on the clutch. In any case, the torque imposed on the clutch should not exceed the torque capacity as shown in the bearing table.

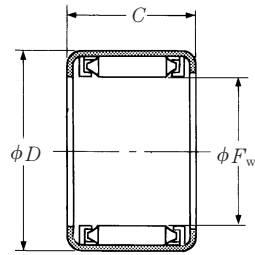
If vibration is involved, the clutch function may be destroyed. Therefore, either refrain from using roller clutches when vibration is involved or attach an effective protection device. Furthermore, for those parts where an accident may cause injury or critical damage, add effective protection devices to the existing equipment.



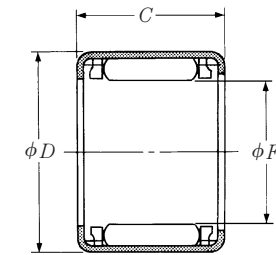
FC · FCL

RC

Shaft Diameter 4 — 30 mm



FC



RC

$F_w$	Boundary Dimensions (mm)				Torque Capacities (N·m) (kgf·m)		
	$D$		$C$ -0.25				
<b>4</b>	8		6		0.31	0.032	
<b>6</b>	10		12		2.45	0.250	
	10		12		1.96	0.200	
<b>6.350</b>	0.2500	11.112	0.4375	12.70	0.5000	1.96	0.200
		11.112	0.4375	12.70	0.5000	1.96	0.200
<b>8</b>	12		12		3.24	0.330	
	14		12		4.02	0.410	
<b>9.525</b>	0.3750	15.875	0.6250	12.70	0.5000	5.10	0.520
		15.875	0.6250	12.70	0.5000	5.10	0.520
<b>10</b>	14		12		4.41	0.450	
	16		12		5.30	0.540	
<b>12</b>	18		16		13.24	1.350	
	<b>12.700</b>	0.5000	19.050	0.7500	12.70	0.5000	8.34
19.050			0.7500	12.70	0.5000	8.34	0.850
<b>14</b>	20		16		14.22	1.450	
	<b>15.875</b>	0.6250	22.225	0.8750	15.88	0.6250	16.18
22.225			0.8750	15.88	0.6250	16.18	1.650
<b>16</b>	22		16		20.59	2.100	
	<b>19.050</b>	0.7500	25.400	1.0000	15.88	0.6250	22.06
25.400			1.0000	15.88	0.6250	22.06	2.250
<b>20</b>	26		16		30.89	3.150	
	<b>25</b>	32		20		68.65	7.000
<b>25.400</b>		1.0000	33.338	1.3125	15.88	0.6250	46.58
	33.338		1.3125	15.88	0.6250	46.58	4.750
<b>30</b>	37		20		95.12	9.700	

Roller Clutch Numbers		Mass (g) approx	Minimum Outside Diameters of Housing (mm)	Matching Support Needle Roller Bearing Numbers	
Metric Design	Inch design			Full Complement	With Cage
<b>FC-4K</b> <sup>(1)</sup>	—	0.90	12	F-48	—
<b>FC-6</b>	—	4.1	14	F-68	FJ-69
<b>FC-6K</b> <sup>(1)</sup>	—	2.7	14	F-68	FJ-69
—	<b>RC-040708</b>	3.6	16	B-45	J-45
—	<b>RC-040708-FS</b> <sup>(2)</sup>	3.6	16	B-45	J-45
<b>FCL-8K</b> <sup>(1)</sup>	—	3.3	18	F-810	FJ-810
<b>FC-8</b>	—	6.8	20	FH-810	FJH-810
—	<b>RC-061008</b>	7.7	22	BH-68	JH-68
—	<b>RC-061008-FS</b> <sup>(2)</sup>	7.7	22	BH-68	JH-68
<b>FCL-10K</b> <sup>(1)</sup>	—	3.9	23	F-1010	FJ-1010
<b>FC-10</b>	—	9.1	25	FH-1010	FJH-1010
<b>FC-12</b>	—	12	27	FH-1212	FJH-1212
—	<b>RC-081208</b>	9.1	28	BH-88	JH-88
—	<b>RC-081208-FS</b> <sup>(2)</sup>	9.1	28	BH-88	JH-88
<b>FC-14K</b> <sup>(1)</sup>	—	16	29	F-1412	FJ-1412
—	<b>RC-101410</b>	14	30	BH-108	JH-108
—	<b>RC-101410-FS</b> <sup>(2)</sup>	14	30	BH-108	JH-108
<b>FC-16</b>	—	18	31	F-1612	FJ-1612
—	<b>RC-121610</b>	15	36	B-1210	J-1210
—	<b>RC-121610-FS</b> <sup>(2)</sup>	15	36	B-1210	J-1210
<b>FC-20</b>	—	21	38	F-2012	FJ-2012
<b>FC-25</b>	—	34	46	F-2516	FJ-2516
—	<b>RC-162110</b>	26	48	BH-168	JH-1612
—	<b>RC-162110-FSS</b> <sup>(2)</sup>	26	48	BH-168	JH-1612
<b>FC-30</b>	—	42	51	F-3020	FJ-3020

Notes <sup>(1)</sup> The suffix K indicates low-torque products.

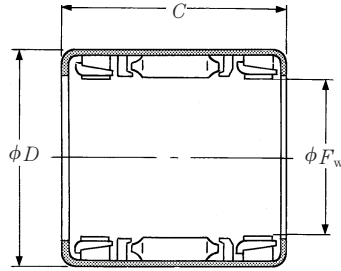
<sup>(2)</sup> Even if the suffix FS is not marked on the product, it can be distinguished from others because its cage is always red.

Remarks For stock availability, please contact NSK. Please consult NSK when making a selection.

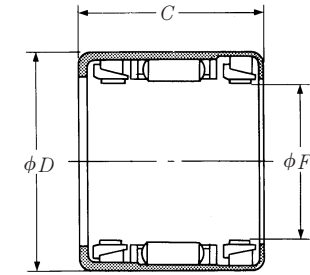
FCB · FCBN

RCB

Shaft Diameter 4 — 30 mm



FCB



RCB

$F_w$	Boundary Dimensions (mm, inch)				Torque Capacities (N·m) (kgf·m)	
	$D$		$C$ -0.25			
<b>4</b>	10		9	0.19	0.019	
<b>6</b>	12		10	0.56	0.057	
<b>8</b>	14		20	4.02	0.410	
<b>9.525</b> 0.3750	15.875	0.6250	22.22	5.10	0.520	
	15.875	0.6250	22.22	5.10	0.520	
<b>10</b>	16		20	5.30	0.540	
<b>12</b>	18		26	13.24	1.350	
	19.050	0.7500	22.22	8.34	0.850	
<b>12.700</b> 0.5000	19.050	0.7500	22.22	8.34	0.850	
	22.225	0.8750	25.40	16.18	1.650	
<b>15.875</b> 0.6250	22.225	0.8750	25.40	16.18	1.650	
	22		26	20.59	2.100	
<b>19.050</b> 0.7500	25.400	1.0000	25.40	22.06	2.250	
	25.400	1.0000	25.40	22.06	2.250	
<b>20</b>	26		26	30.89	3.150	
	32		30	68.65	7.000	
<b>25</b> <b>25.400</b> 1.0000	33.338	1.3125	27.00	46.58	4.750	
	33.338	1.3125	27.00	46.58	4.750	
	37		30	95.12	9.700	

Roller Clutch Numbers		Basic Dynamic Load Ratings (N) $C_r$ (kgf)		Limiting Loads (N) $P_{max}$ (kgf)		Mass (g) approx	Minimum Outside Diameters of Housing (mm)
Metric Design	Inch design						
<b>FCBN-4K</b> <sup>(1)</sup>	—	1 190	121	540	55	2.7	16
<b>FCBN-6K</b> <sup>(1)</sup>	—	1 630	166	735	75	3.8	18
<b>FCB-8</b>	—	2 430	248	1 200	122	11	20
—	<b>RCB-061014</b>	3 700	375	2 010	205	14	22
—	<b>RCB-061014-FS</b> <sup>(2)</sup>	3 700	375	2 010	205	14	22
<b>FCB-10</b>	—	2 820	288	1 450	148	13	25
<b>FCB-12</b>	—	3 800	390	2 240	228	18	27
—	<b>RCB-081214</b>	4 400	450	2 580	263	16	28
—	<b>RCB-081214-FS</b> <sup>(2)</sup>	4 400	450	2 580	263	16	28
—	<b>RCB-101416</b>	4 900	500	3 050	310	23	30
—	<b>RCB-101416-FS</b> <sup>(2)</sup>	4 900	500	3 050	310	23	30
<b>FCB-16</b>	—	4 100	420	2 670	272	24	31
—	<b>RCB-121616</b>	5 550	565	3 700	375	26	36
—	<b>RCB-121616-FS</b> <sup>(2)</sup>	5 550	565	3 700	375	26	36
<b>FCB-20</b>	—	5 100	520	3 550	360	28	38
<b>FCB-25</b>	—	6 850	700	4 700	480	48	46
—	<b>RCB-162117</b>	9 750	995	6 750	690	45	48
—	<b>RCB-162117-FS</b> <sup>(2)</sup>	9 750	995	6 750	690	45	48
<b>FCB-30</b>	—	7 000	715	5 250	535	54	51

**Notes** <sup>(1)</sup> The suffix K indicates low-torque products.

<sup>(2)</sup> Even if the suffix FS is not marked on the product, it can be distinguished from others because its cage is always red.

**Remarks** For stock availability, please contact NSK. Please consult NSK when making a selection.

## OIL SEALS FOR NEEDLE BEARINGS

Pages

Single-Lip Synthetic Rubber Seals .....	B242
Double-Lip Synthetic Rubber Seals.....	B242

Needle roller bearing oil seals are manufactured to meet the section height of drawn cup needle bearings. It is possible, therefore, to mount them onto the side face of a needle bearing without specially machining the housing bore.

The oil seals of VC and KC bearings serve as packing because their outside circumferences are rubber and facilitate easy mounting.

### Types

The types of needle roller bearing oil seals are shown in **Table 1**.

**Table 1 Types of Oil Seals**

Type	Details	
VC	Synthetic rubber	Single lip
KC	Synthetic rubber	Double lip

### Accuracy

The dimensional tolerance of oil seals complies with ISO6194 (JIS B 2402). The outside diameter and the width tolerances are shown in **Table 2** and **Table 3**, respectively.

**Table 2 Outside Diameter Tolerance**

Units: mm

Nominal Outside Diameter		Tolerance	
over	incl	high	low
—	30	+0.30	+0.10
30	120	+0.35	+0.10

**Table 3 Width Tolerance**

Units: mm

Nominal Width		Width Tolerance	
over	incl	high	low
—	6	+0.2	-0.2



## APPLICATIONS

### Mounting

When single-lip VC bearings are mounted, the lip should be bent inward to prevent lubricant leakage and outward to prevent entry of foreign matter.

Double-lip KC bearings, which have good sealing properties and high resistance to foreign particles, emphasize the prevention of entry of foreign matter and are provided with sufficient interference, so the main lip should be bent outward.

As wear and heat are easily generated if there is no oil film between the seal lip and the shaft, a coating of oil must be applied to the seal when mounting.

When press fitting the seal into the housing as prescribed, any shock that may cause deformation to the seal should be avoided. It is recommended to use a press-fitting jig that is capable of equally pushing the whole back face of the seal (Fig. 1).

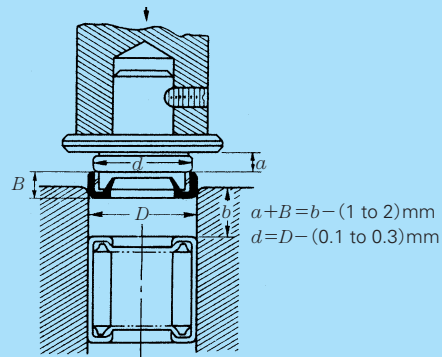


Fig. 1

### Mounting on Shaft

If there is no slope in the shaft end or there is a key way or screw thread, the lip can be protected from any damage or peeling by using a bush as shown in Fig. 2, since the bore diameter of the seal is less than the shaft diameter.

Coating grease onto the lip can make mounting easier and protect it. It is recommended that the shaft end to which the seal is mounted should be chamfered at about 30 degrees.

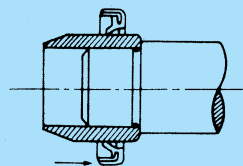


Fig. 2

### Limiting Speed

Limiting speed, which varies depending on the eccentricity of the shaft in contact and roughness of the finished face, is generally 10 m/sec for VC and 6 m/sec for KC bearings. In the case of outer ring rotation, it should be half of the above values. The maximum operating temperature is about 120°C for short periods of operation.

A typical example of oil seal mounting is shown in Fig. 3.

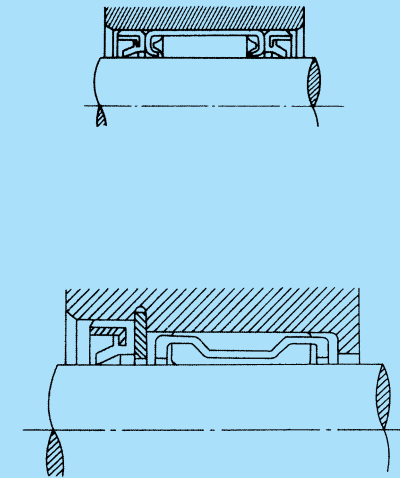
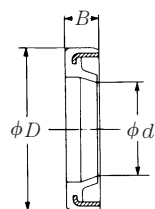
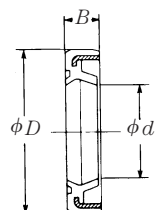


Fig. 3 Typical Examples of Oil Seal Mounting



VC



KC

	Boundary Dimensions (mm)			Oil Seal Numbers	
	<i>d</i>	<i>D</i>	<i>B</i>	VC	KC
<b>4</b>	8	2.5		<b>VC-4825</b>	—
<b>5</b>	9	2.5		<b>VC-5925</b>	—
<b>6</b>	10	2.5		<b>VC-61025</b>	—
<b>7</b>	11	2.5		<b>VC-71125</b>	—
<b>8</b>	12	2.5		<b>VC-81225</b>	—
	15	3		<b>VC-8153</b>	—
<b>9</b>	13	2.5		<b>VC-91325</b>	—
	16	3		<b>VC-9163</b>	—
<b>10</b>	14	2.5		<b>VC-101425</b>	—
	17	3		<b>VC-10173</b>	—
<b>12</b>	16	2.5		<b>VC-121625</b>	—
	18	3		<b>VC-12183</b>	—
	19	3		<b>VC-12193</b>	—
<b>13</b>	19	3		<b>VC-13193</b>	—
<b>14</b>	20	3		<b>VC-14203</b>	<b>KC-14203</b>
	22	3		<b>VC-14223</b>	<b>KC-14223</b>
<b>15</b>	21	3		<b>VC-15213</b>	<b>KC-15213</b>
	22	3		<b>VC-15223</b>	<b>KC-15223</b>
<b>16</b>	22	3		<b>VC-16223</b>	<b>KC-16223</b>
	24	3		<b>VC-16243</b>	<b>KC-16243</b>
<b>17</b>	23	3		<b>VC-17233</b>	<b>KC-17233</b>
	24	3		<b>VC-17243</b>	<b>KC-17243</b>
<b>18</b>	24	3		<b>VC-18243</b>	<b>KC-18243</b>
	25	3		<b>VC-18253</b>	<b>KC-18253</b>
<b>20</b>	26	4		<b>VC-20264</b>	<b>KC-20264</b>
	27	4		<b>VC-20274</b>	<b>KC-20274</b>
<b>22</b>	28	4		<b>VC-22284</b>	<b>KC-22284</b>
	29	4		<b>VC-22294</b>	<b>KC-22294</b>
<b>25</b>	32	4		<b>VC-25324</b>	<b>KC-25324</b>
	33	4		<b>VC-25334</b>	<b>KC-25334</b>
<b>28</b>	35	4		<b>VC-28354</b>	<b>KC-28354</b>
	37	4		<b>VC-28374</b>	<b>KC-28374</b>
<b>30</b>	37	4		<b>VC-30374</b>	<b>KC-30374</b>
	40	4		<b>VC-30404</b>	<b>KC-30404</b>
<b>32</b>	42	4		<b>VC-32424</b>	<b>KC-32424</b>
<b>35</b>	42	4		<b>VC-35424</b>	<b>KC-35424</b>
	45	4		<b>VC-35454</b>	<b>KC-35454</b>
<b>40</b>	47	4		<b>VC-40474</b>	<b>KC-40474</b>
	50	4		<b>VC-40504</b>	<b>KC-40504</b>
<b>45</b>	52	4		<b>VC-45524</b>	<b>KC-45524</b>
	55	4		<b>VC-45554</b>	<b>KC-45554</b>
<b>50</b>	62	4		<b>VC-50624</b>	<b>KC-50624</b>

EXAMPLE FIGURES

APPENDICES

FIGURES

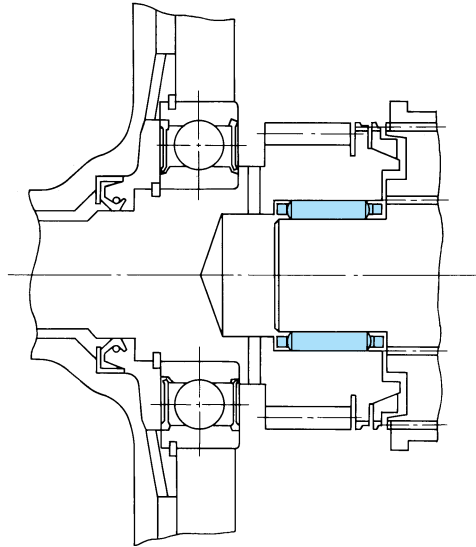
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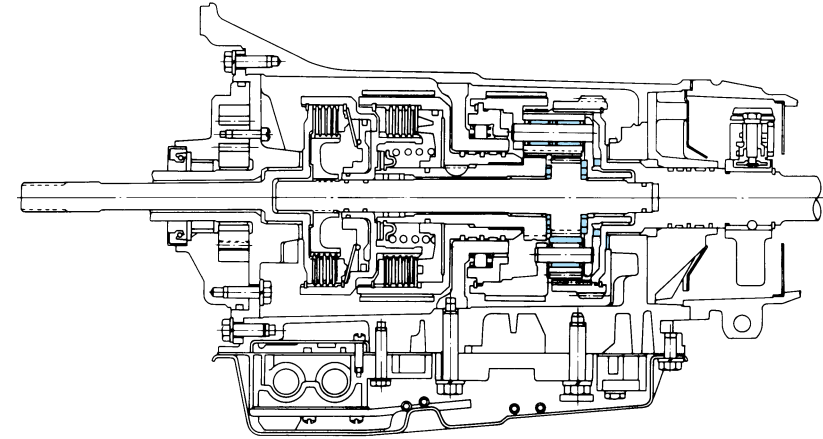
Please consult NSK when making a selection.

MOTOR VEHICLES



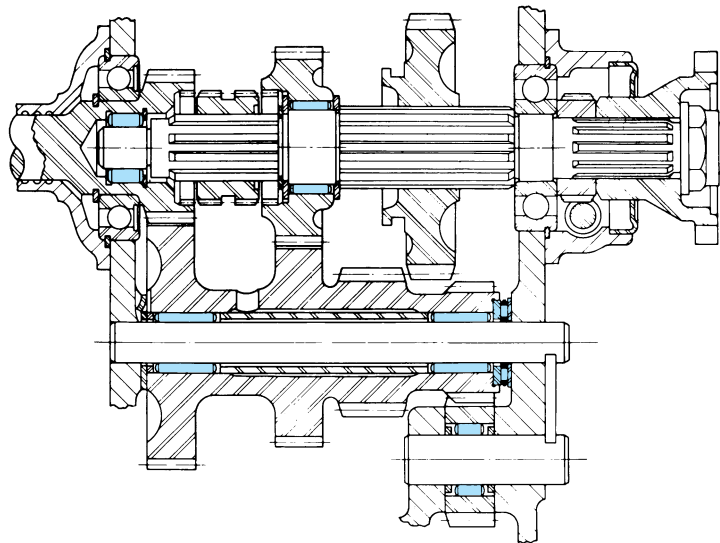
**Fig. 1 Transmission Pilot**

This illustrates the application of cage & needle roller assemblies in the transmission pilot. Due to considerable misalignment, it is desirable to provide a radial internal clearance of at least 0.038 mm.



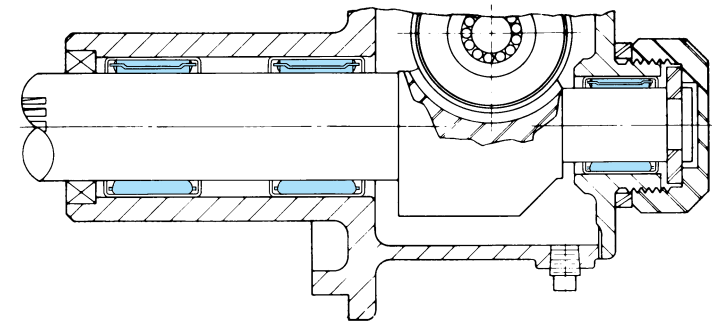
**Fig. 3 Automatic Transmission**

This illustrates a typical application in automatic transmissions. In particular, since thrust from the output shaft is expected, a thrust needle roller bearing with a large roller diameter is applied to the output shaft. A full complement is applied to the planetary gear. These rollers are usually treated with special crowning.

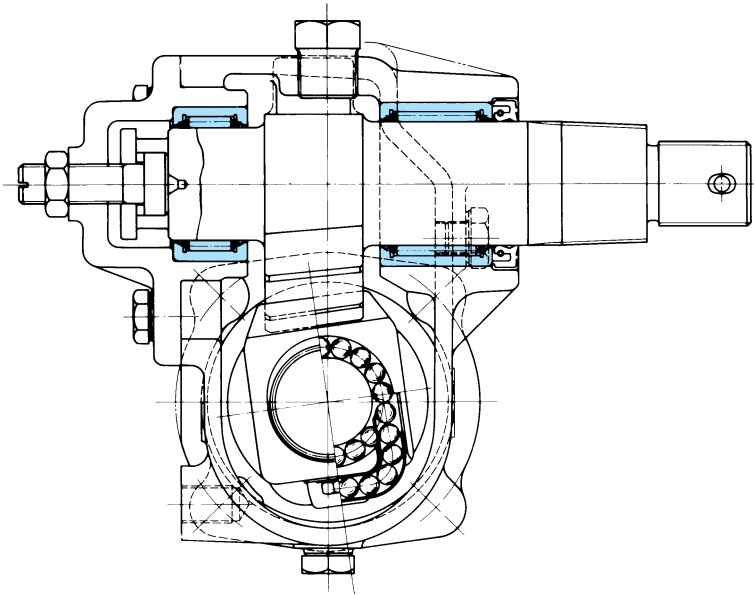


**Fig. 2 Constant Mesh Transmission**

This illustrates the application of needle rollers to the countershaft or main idler gear. In many cases, cage & needle roller assemblies are applied instead of needle rollers.

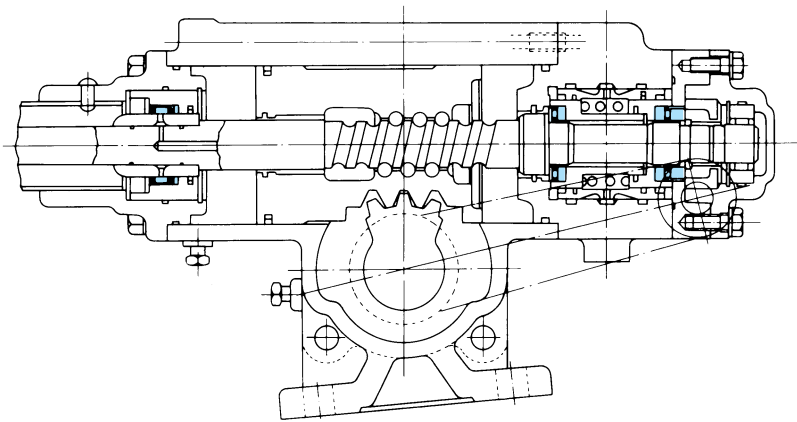


**Fig. 4 Manual Steering System**



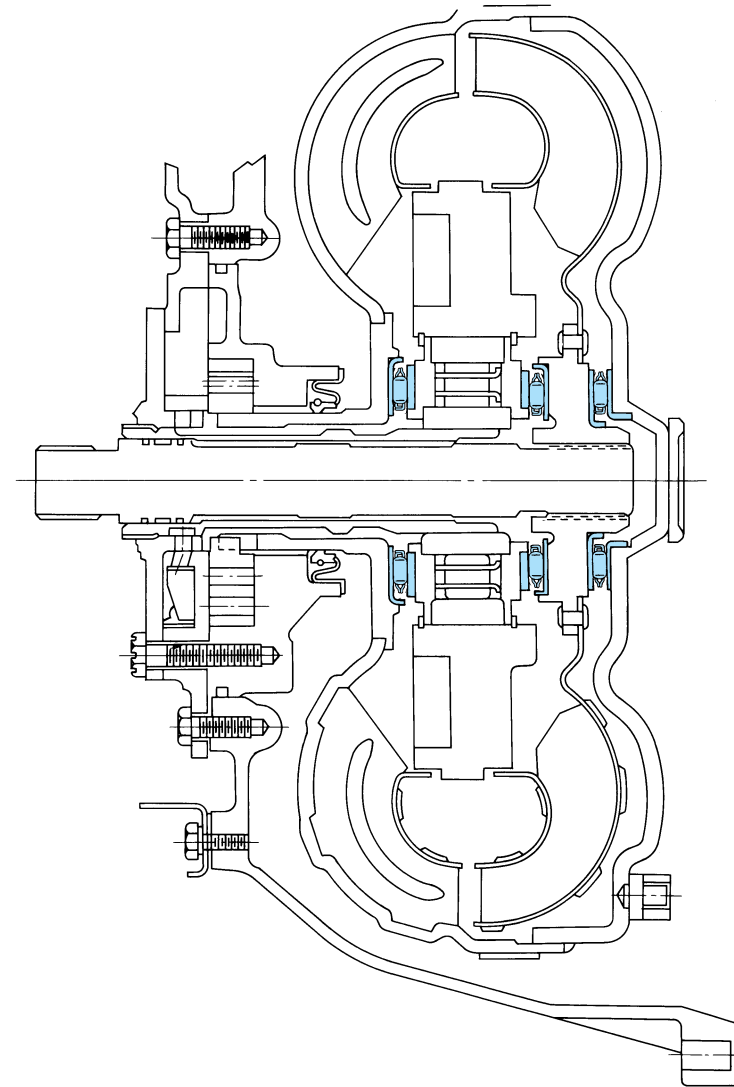
**Fig. 5 Ball Screw Steering Sector Shaft**

For large trucks and buses, solid bearings are used. For passenger cars, however, drawn cup needle roller bearings are applied in many cases.

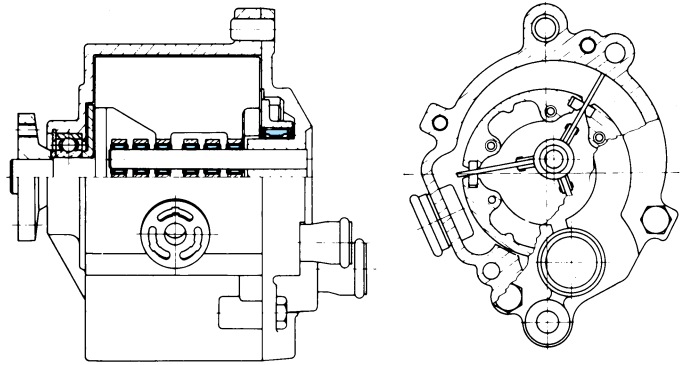


**Fig. 6 Power Steering Systems**

Drawn cup needle roller bearings and thrust needle roller bearings are applied to the hydraulic mechanism in power steering systems.

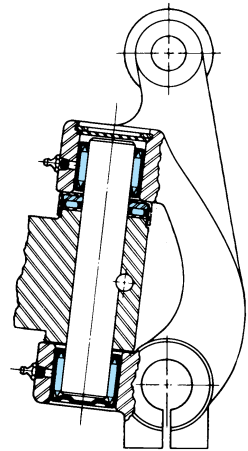


**Fig. 7 Torque Converter**



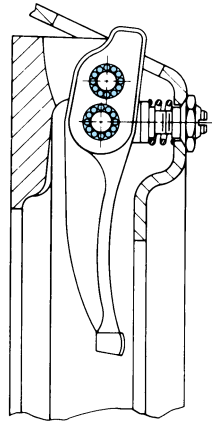
**Fig. 8 Air Pump (3-vane)**

In order to reduce size and weight, drawn cup needle roller bearings with a cage are applied to the vanes and rotor shaft. A two-vane type is also available.

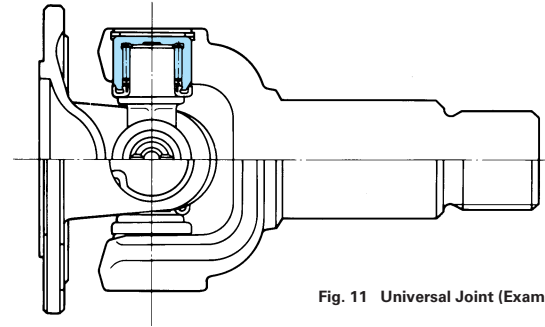


**Fig. 9 Kingpin**

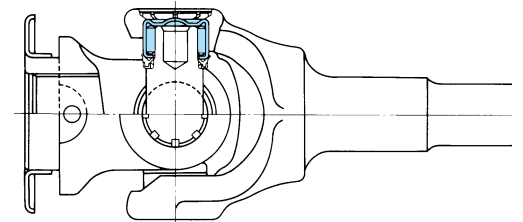
Drawn cup needle roller bearings are applied to the kingpin. In some cases, a grease nipple is attached for lubrication.



**Fig. 10 Clutch Finger**

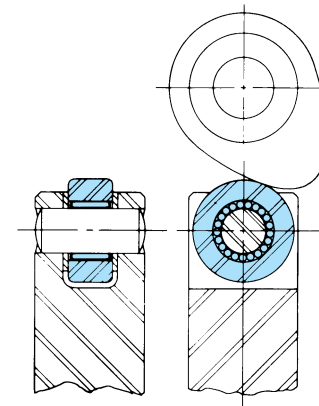


**Fig. 11 Universal Joint (Example of Solid Bearing Application)**



**Fig. 13 Universal Joint (Example of Drawn Cup Bearing Application)**

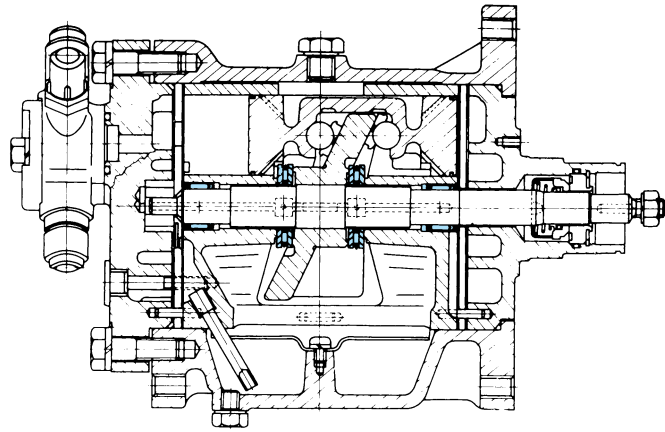
This illustrates an application of drawn cup needle roller bearings in a universal joint to reduce size, weight and cost.



**Fig. 12 Engine Camshaft Follower**

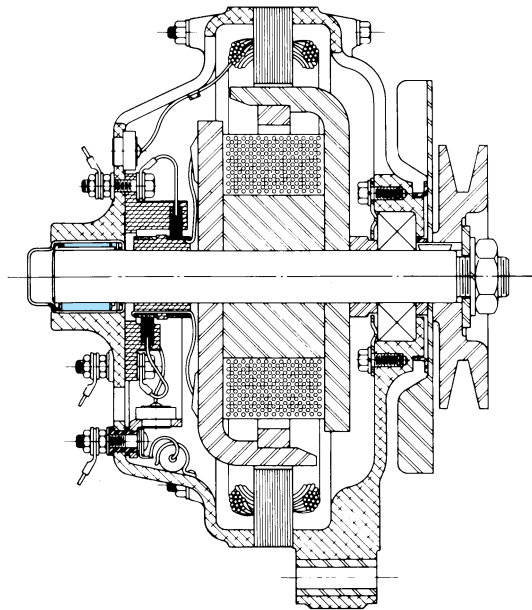


CONSTRUCTION AND CARGO HANDLING EQUIPMENT



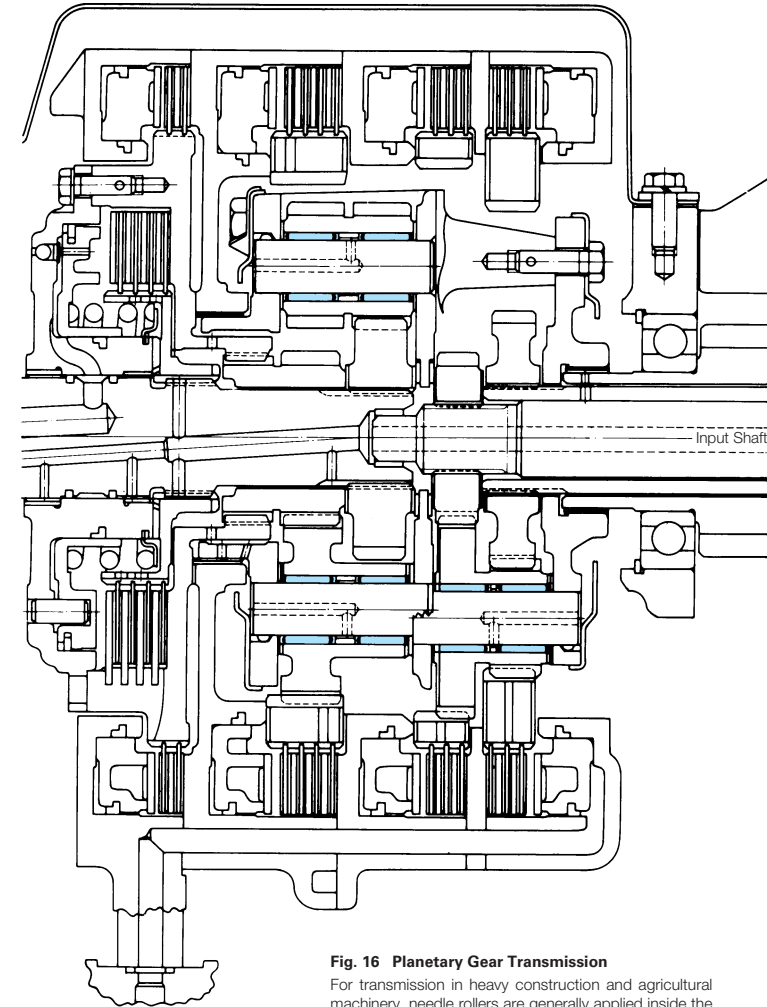
**Fig. 14 Automotive Air-Conditioner Compressor**

This illustrates the application in the compressor of a swash plate air conditioner, with a characteristic structure involving support by a thrust bearing.



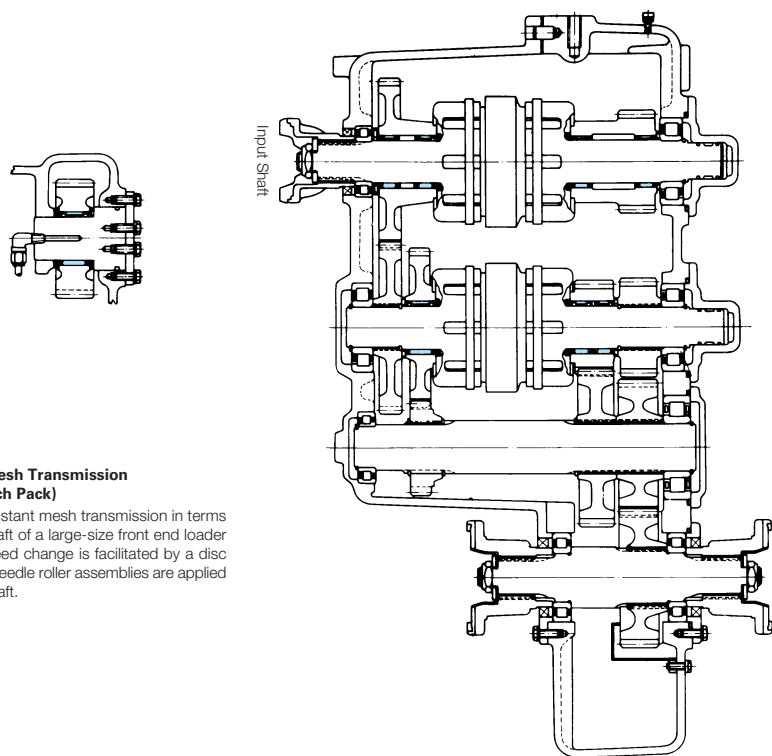
**Fig. 15 Alternator (AC Generator)**

A drawn cup needle roller bearing with a cage is applied on the opposite side of the pulley to reduce size, weight and cost.



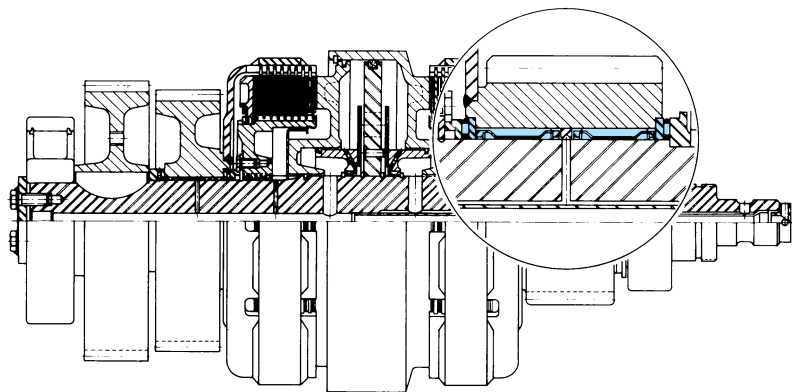
**Fig. 16 Planetary Gear Transmission**

For transmission in heavy construction and agricultural machinery, needle rollers are generally applied inside the planetary gear and placed in two rows for stability. For assembly reasons, cage & needle roller assemblies are also used.



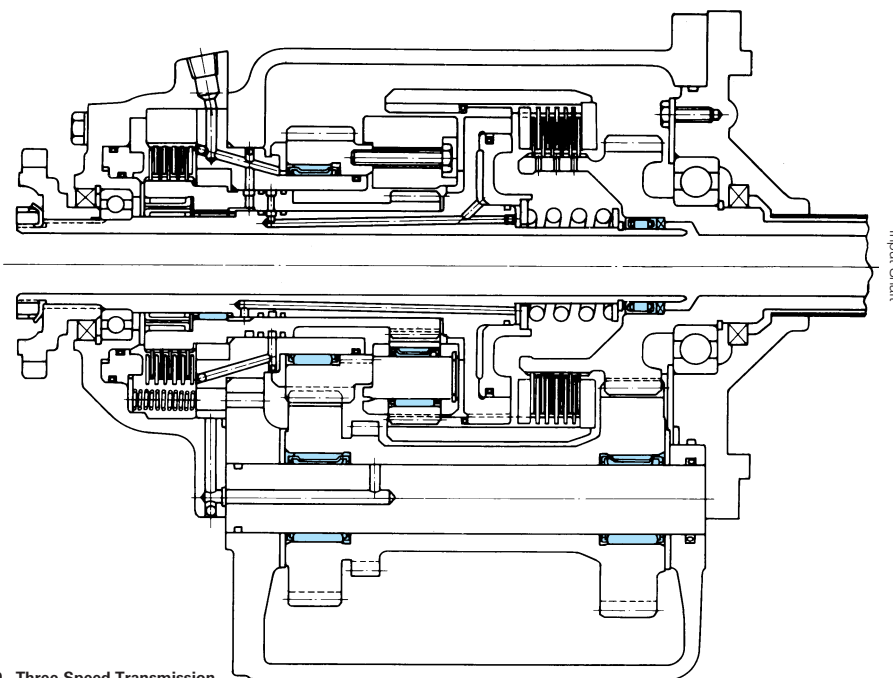
**Fig. 17 Constant Mesh Transmission (Using Clutch Pack)**

This illustrates the constant mesh transmission in terms of the intermediate shaft of a large-size front end loader with rubber tires. Speed change is facilitated by a disc clutch pack. Cage & needle roller assemblies are applied to this intermediate shaft.



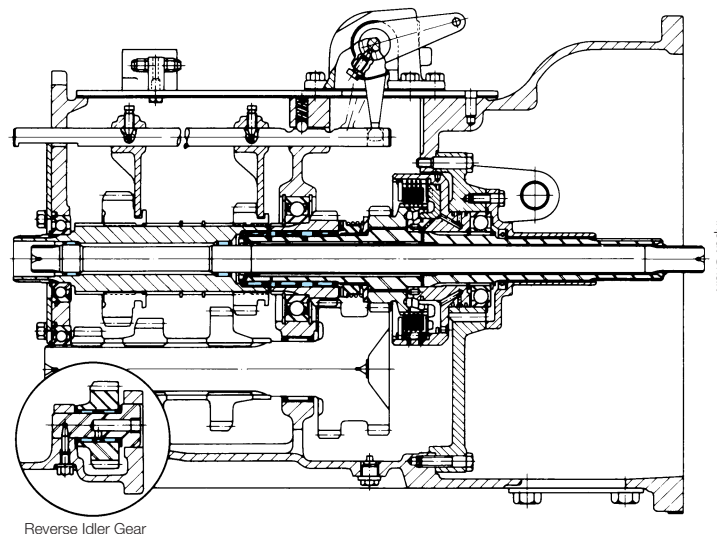
**Fig. 18 Detailed Drawing of Clutch Pack**

Two units of cage & needle roller assemblies are commonly applied to the gear support of the clutch pack. This bearing usually runs with a light load or without any load and does not run if a load is imposed. In such an application, a bearing with a static load rating of 4 to 7 times that of the static load should be selected.



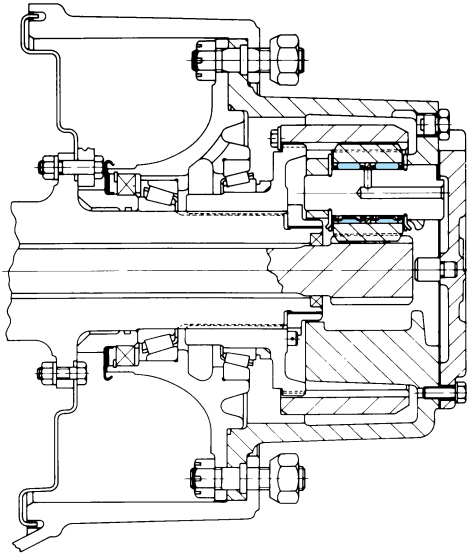
**Fig. 19 Three-Speed Transmission**

The figure shows an example of the three-speed transmission of a garden tractor or the like. Cage & needle roller assemblies are applied to the countershaft and planetary gear. Cage & needle roller assemblies are also used as clutch support on the right-hand side of a one-way clutch.



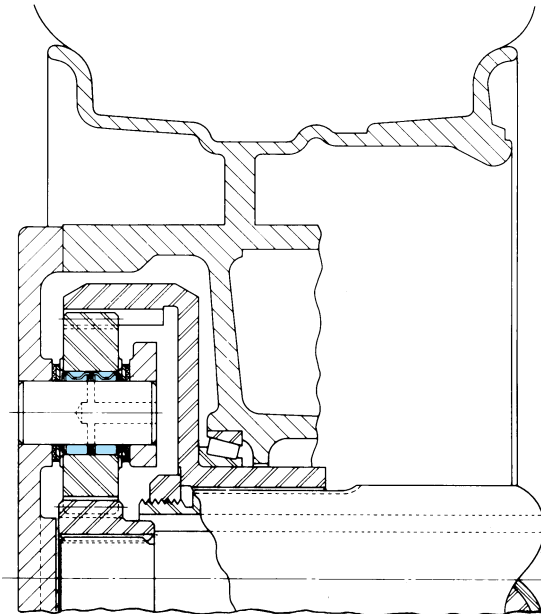
**Fig. 20 Six-Speed Transmission**

The figure shows a six-speed sliding mesh transmission, which is basically a three-speed transmission with a two-speed power shift in the earlier stage.



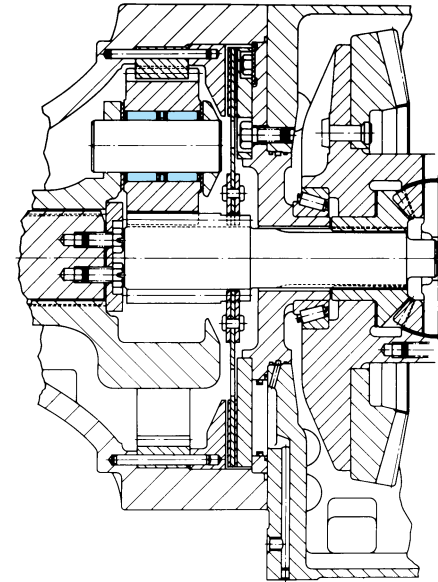
**Fig. 21 Final Reduction Gear for Large Tractor**

For rubber-tire tractors used in construction, a planetary final reduction gear is used as shown in the figure. In this case, since the load is large and space is limited, cage & needle roller assemblies are used in consideration of the large load capacity, compact size, assembly, and service.



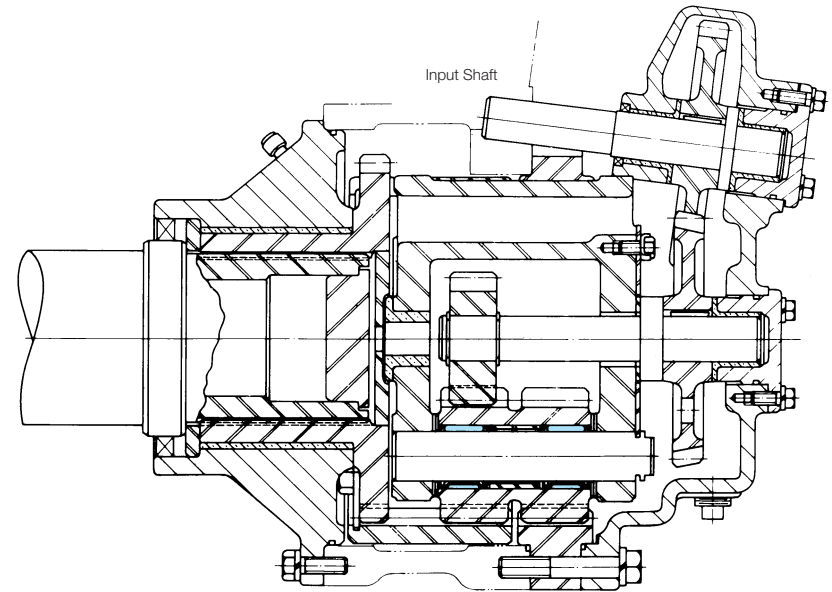
**Fig. 22 Final Reduction Gear**

The structure is similar to Fig. 21. Two rows of cage & needle roller assemblies are also applied to this device to enhance the stability of the gears. Rollers treated with a proper crowning are recommended.



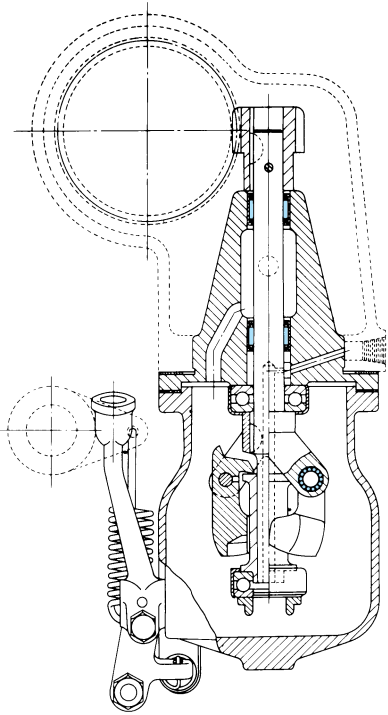
**Fig. 23 Final Reduction Gear**

In some cases, a final reduction gear is positioned close to the differential gears as shown in this figure. Instead of cage & needle roller assemblies, a single needle roller bearing is integrated into the two rows and the rollers are kept separate by a hardened spacer. It is absolutely essential that the needle rollers have the proper crowning.

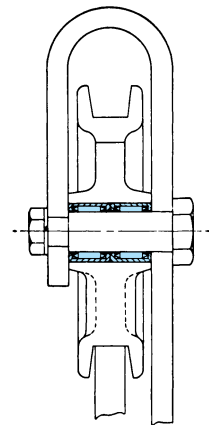


**Fig. 24 Auxiliary Gearbox**

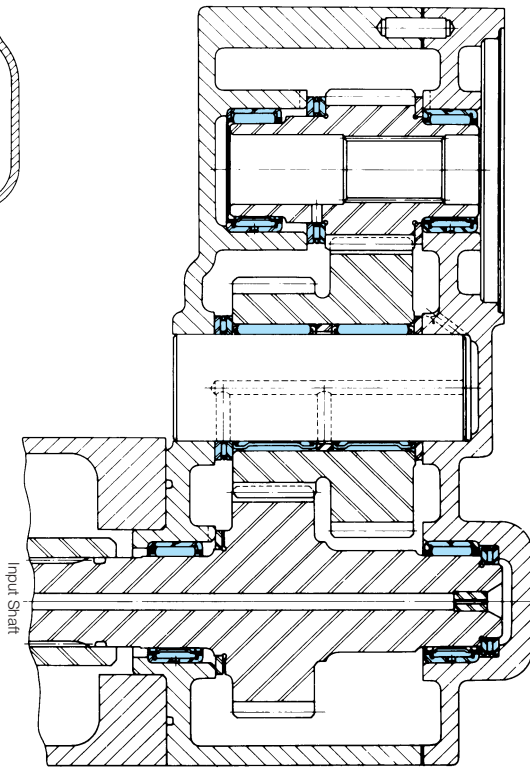
This illustrates an application of cage & needle roller assemblies to the planetary gears of an auxiliary gearbox.



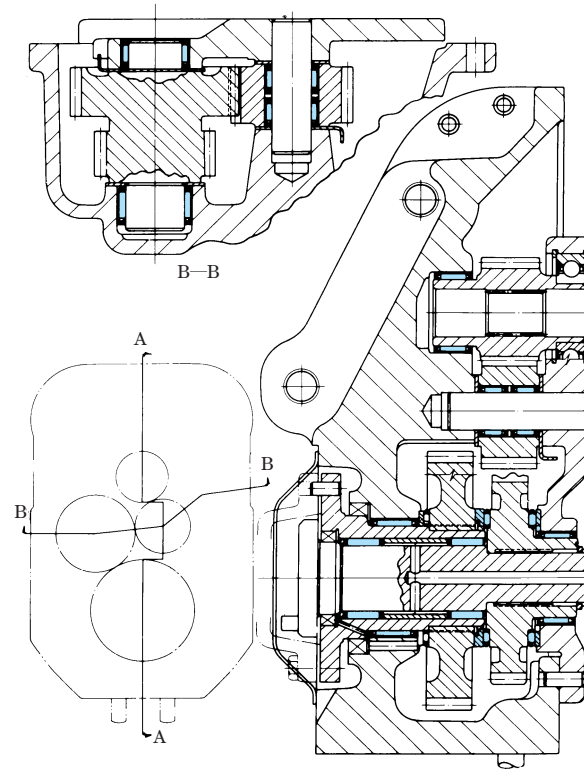
**Fig. 25 Governor**  
The governor of a diesel engine is one of the parts where fretting corrosion or false brinelling is easily caused by vibration. In the figure, a drawn cup, full complement bearing is applied to the pivot arm.



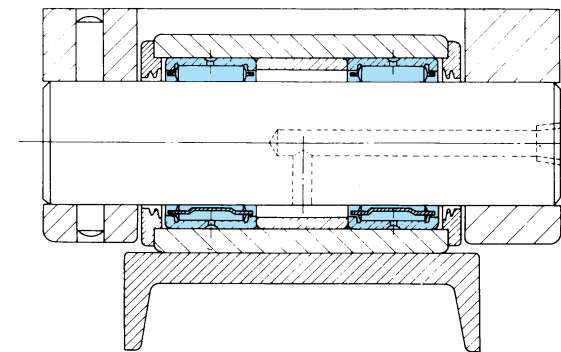
**Fig. 26 Sheave for Cargo Handling Vehicle**



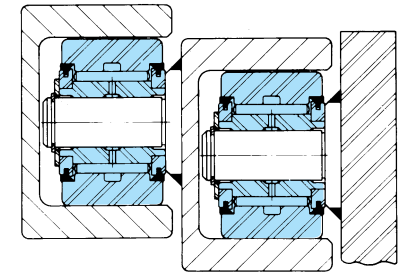
**Fig. 27 Hydraulic Pump Drive Unit**  
For hydraulic pump drive units in equipment such as large scrapers, which generally use aluminum or copper alloy metal, if forced lubrication is not possible, the application of a needle roller bearing facilitates lubrication as shown in the figure.



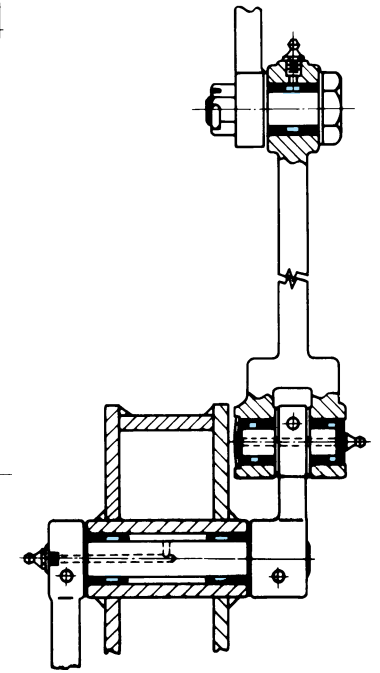
**Fig. 28 Two-Speed Transmission PTO Unit**  
The power take-off (PTO) of a large two-speed tractor for agricultural use is successfully designed very compactly with a combination of drawn cup needle roller bearings and thrust bearings.



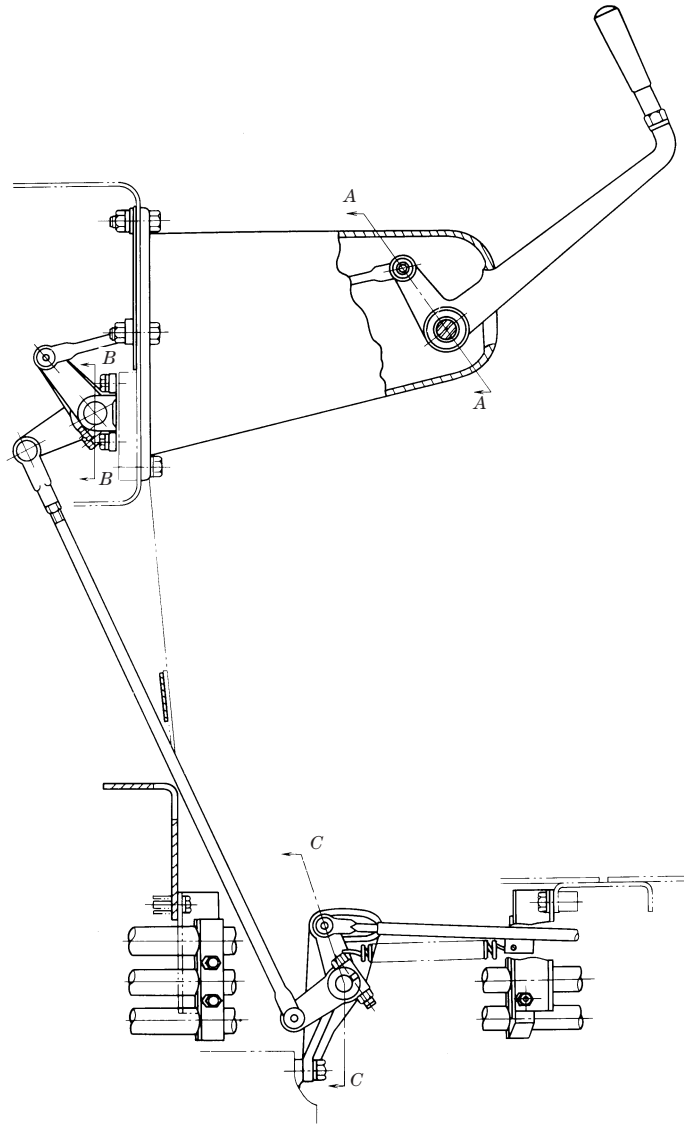
**Fig. 30 Forklift and Truck Roller**



**Fig. 29 Truck Roller in Forklifts**

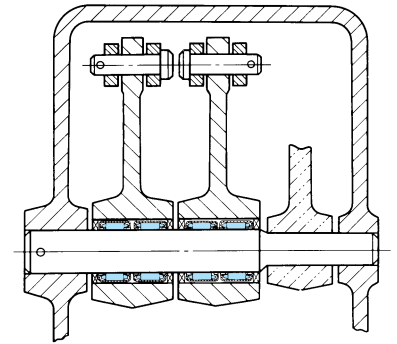


**Fig. 31 Control System Linkage**

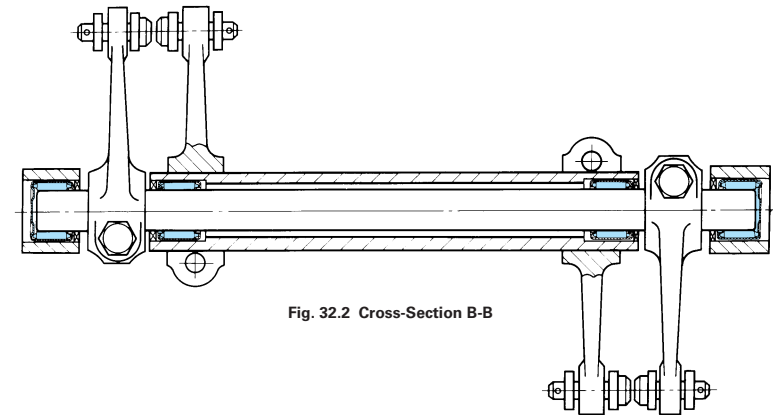


**Fig. 32 Control Lever System**

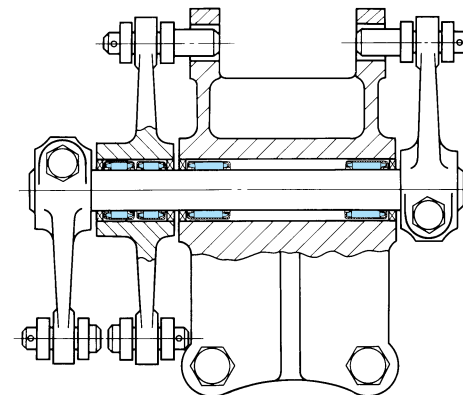
For the control lever system in equipment such as construction machinery, there has been a switch from plain metal to needle roller bearings for smoother performance and lubrication. Depending on the applicable part, due consideration is sought for enabling re-lubrication. Detailed cross-sectional drawings for each part are shown on the following page.



**Fig. 32.1 Cross-Section A-A**



**Fig. 32.2 Cross-Section B-B**



**Fig. 32.3 Cross-Section C-C**

AGRICULTURAL MACHINERY

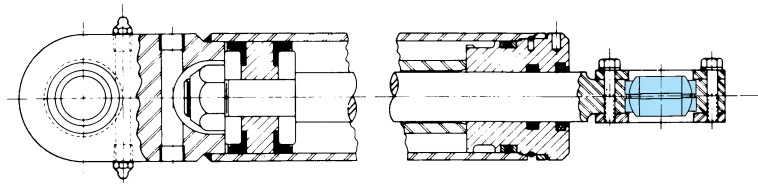


Fig. 33 Hydraulic Cylinder for Bulldozer Blade Operation

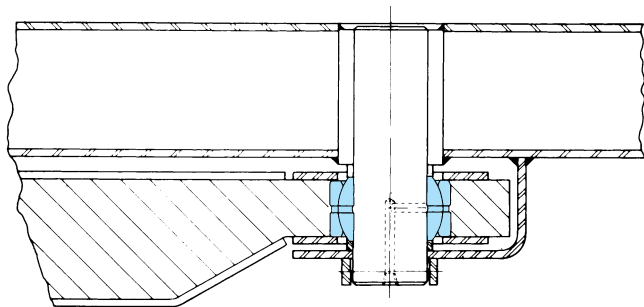


Fig. 34 Scraper Linkage

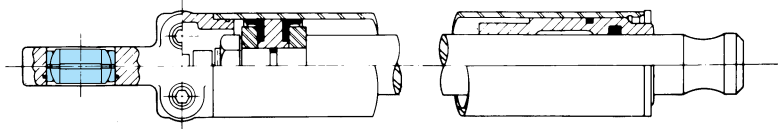


Fig. 35 Hydraulic Cylinder for Shovel Operation

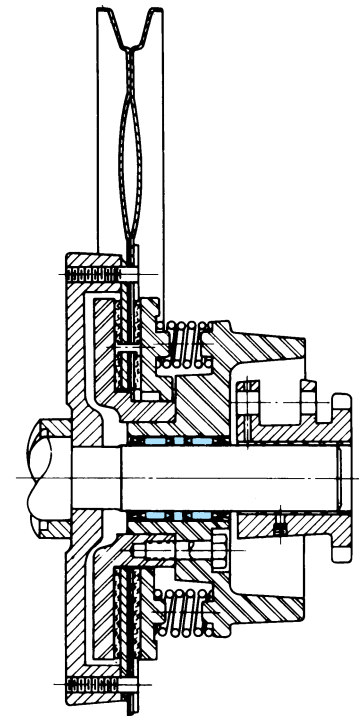


Fig. 36 Grain Reaping Machine

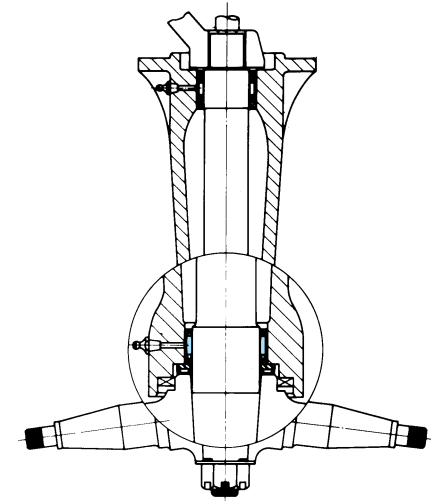


Fig. 37 Tractor Bolster

A compact thrust needle roller bearing is applied to the thrust pad of a tractor bolster. A drawn cup needle roller bearing is also used at the same time for smoother operation.

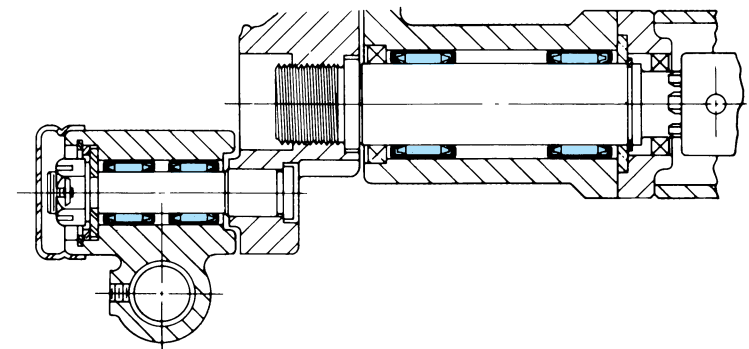


Fig. 38 Pitman

For superior wear resistance and operating efficiency, a drawn cup needle roller bearing is applied to the pitman crank and crankpin.

MACHINE TOOLS

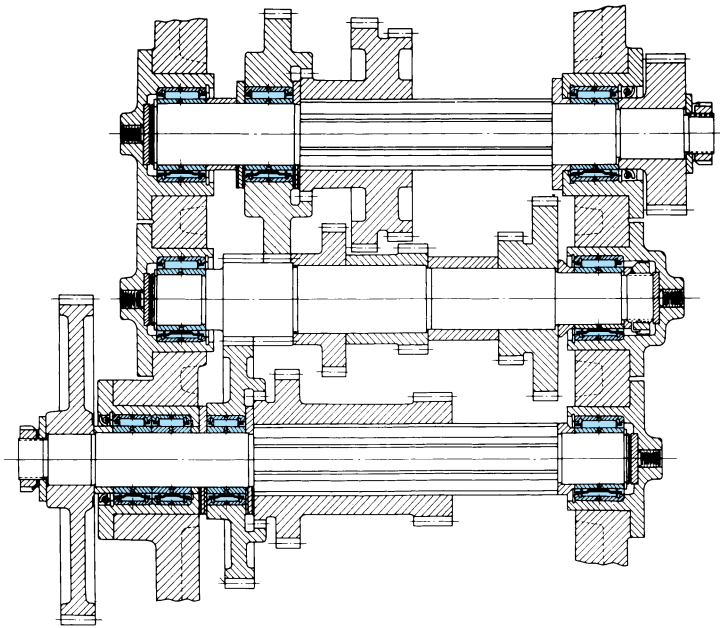


Fig. 39 Machine Tool Gearbox

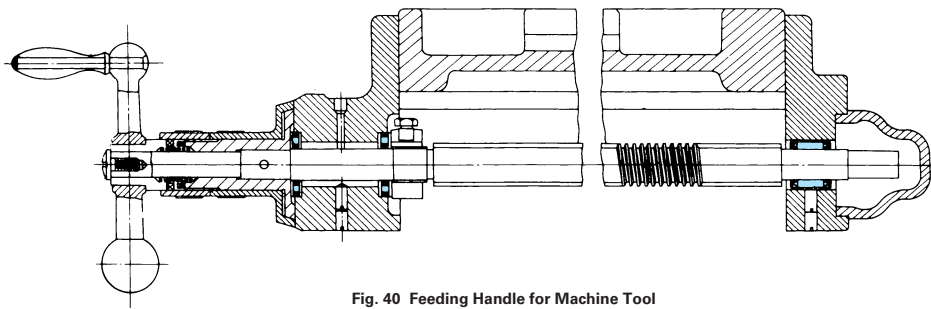


Fig. 40 Feeding Handle for Machine Tool

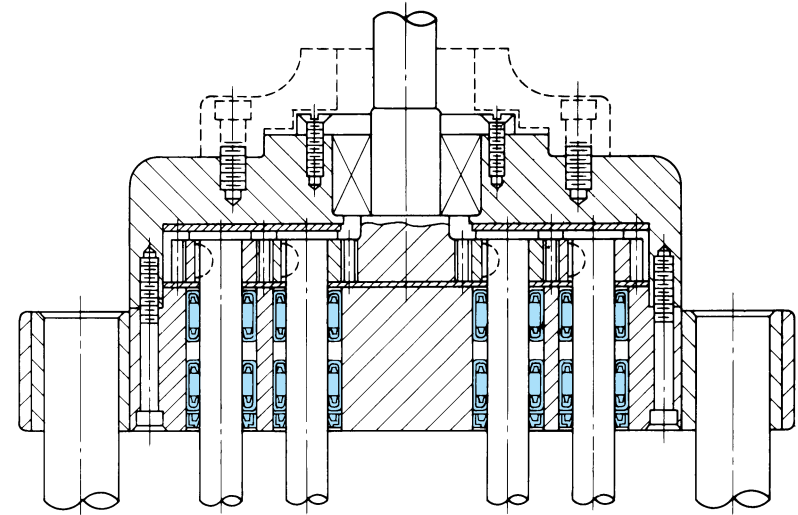


Fig. 41 Multi-Spindle Drill

In the case of multiple spindles occupying a limited space, such as a multiple spindle drilling machine, a drawn cup needle roller bearing is recommended.

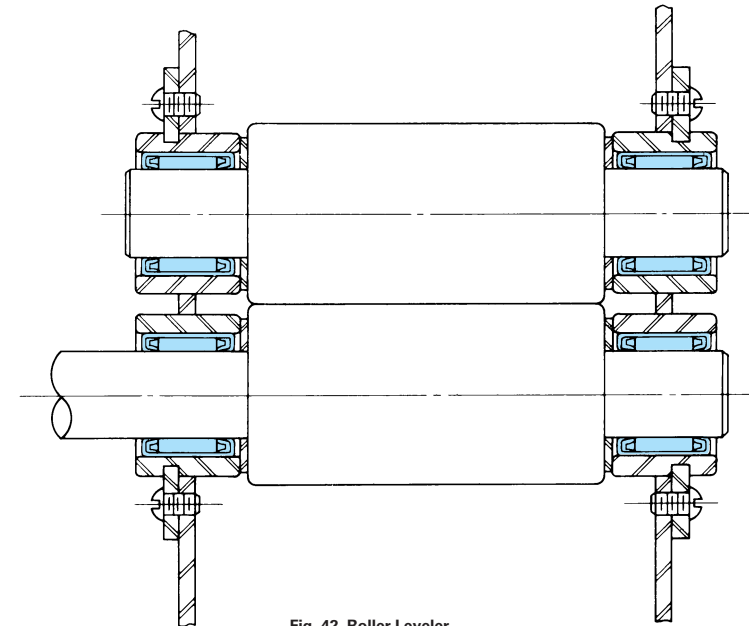


Fig. 42 Roller Leveler

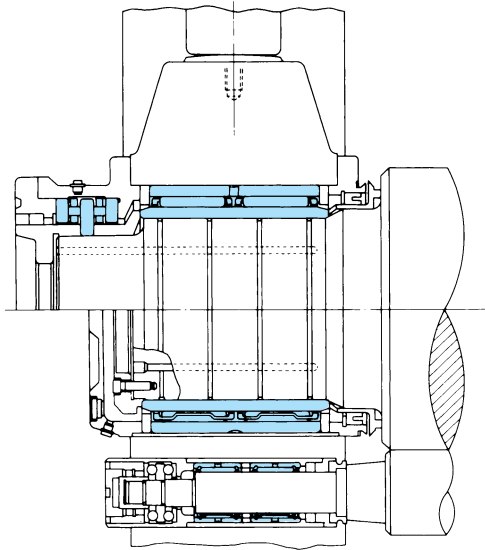


Fig. 43 Back-Up Roll and Working Roll

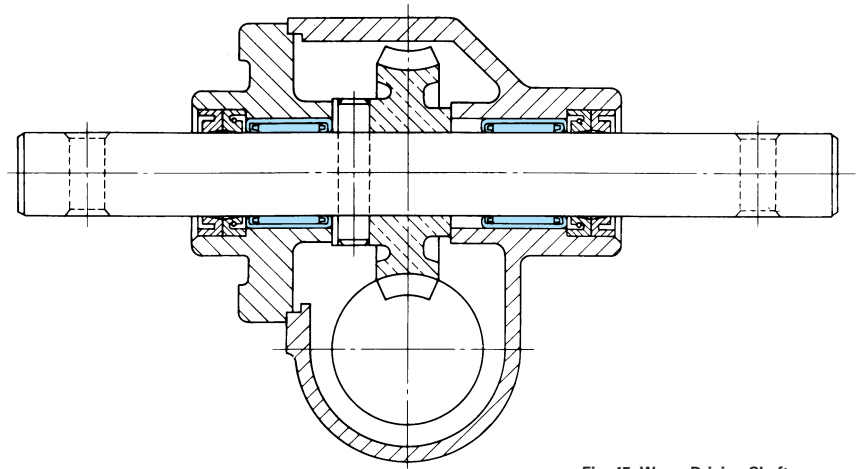


Fig. 45 Worm Driving Shaft

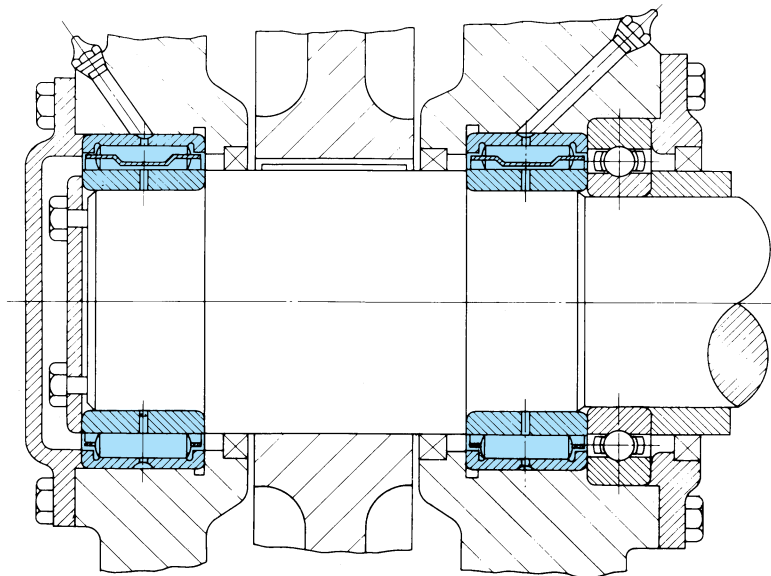


Fig. 44 Crane Wheel

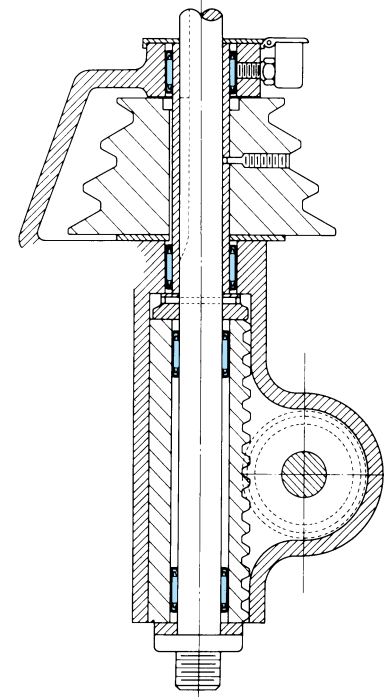


Fig. 46 Small Drill Press Spindle



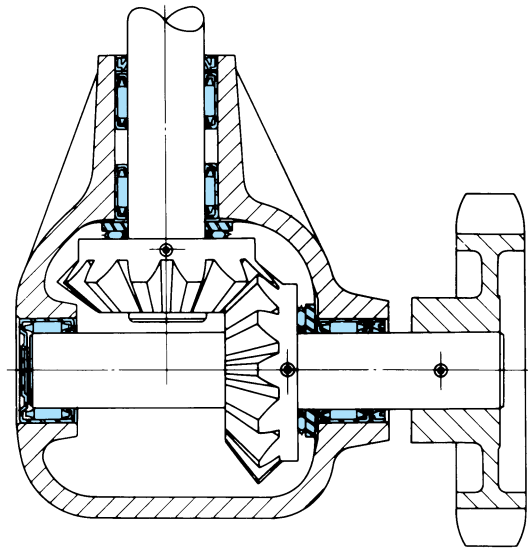


Fig. 47 Gearbox

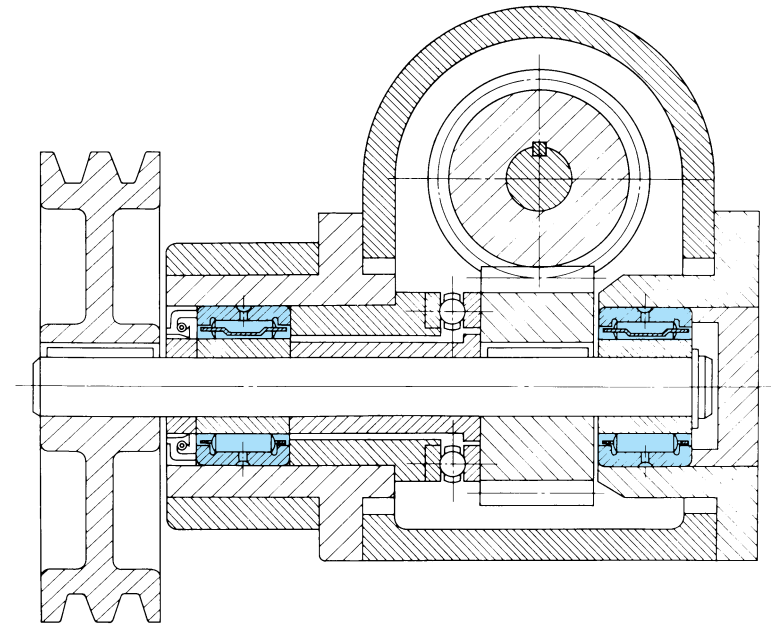


Fig. 49 Conveyer Driving Reduction Gear

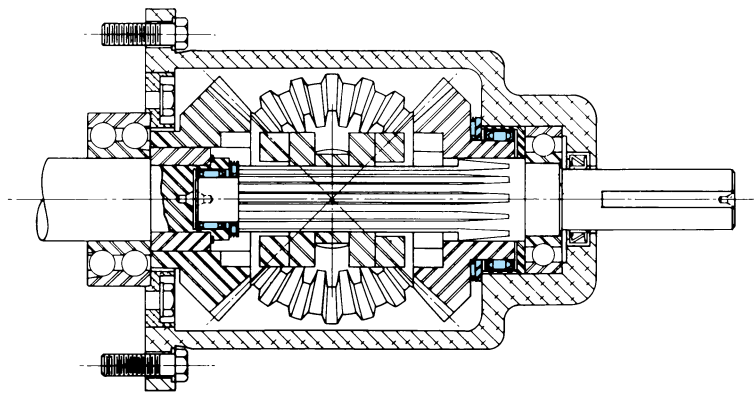


Fig. 48 Gearbox

BUSINESS MACHINES

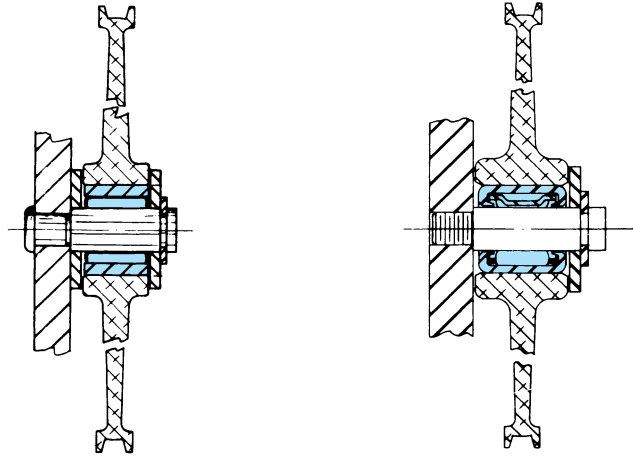


Fig. 50 Magnetic Tape Driving Pulley for Electronic Computers

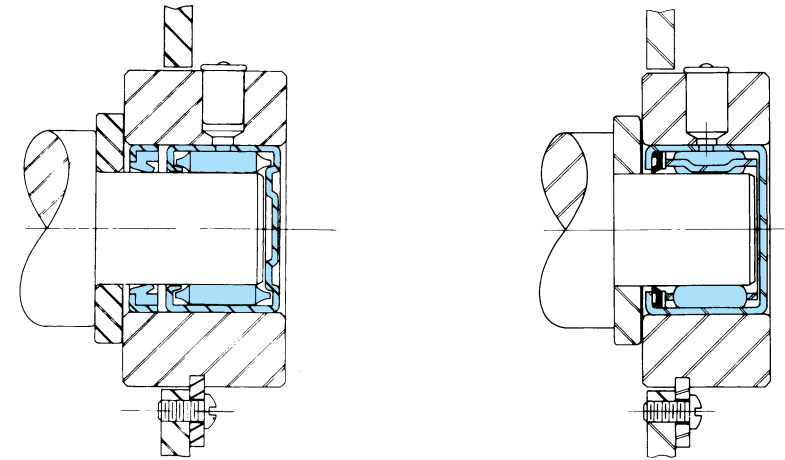


Fig. 52 Copying Machine Side Frame

The application of a closed drawn cup needle roller bearing to the shaft end contributes to cost reduction and enhancement of seal performance.

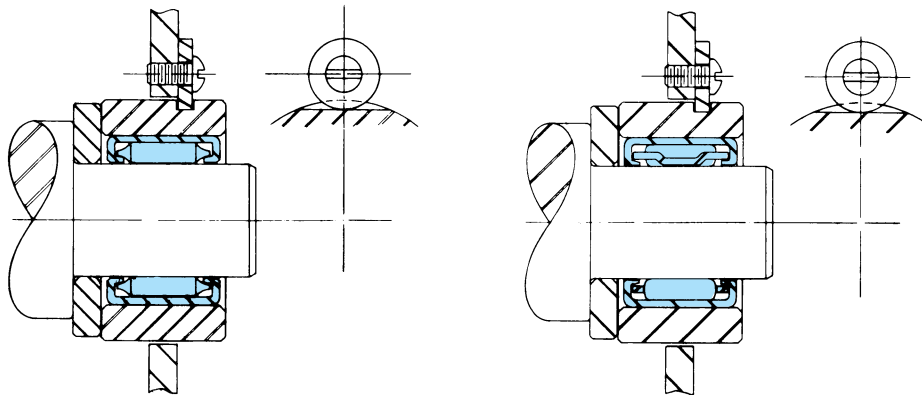


Fig. 51 Copying Machine Side Frame

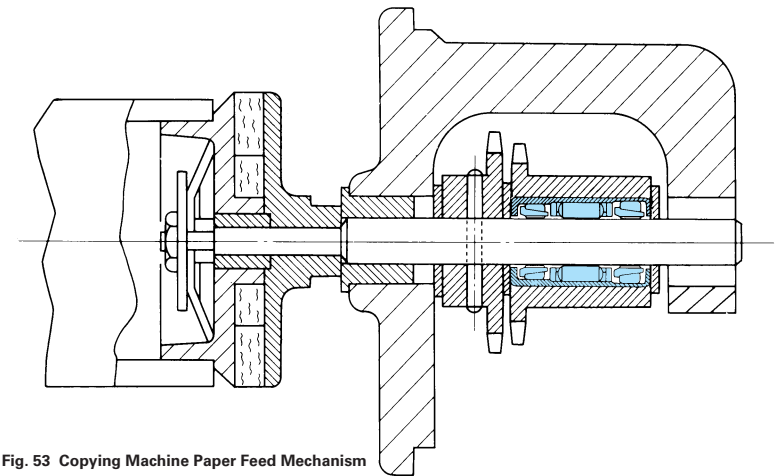
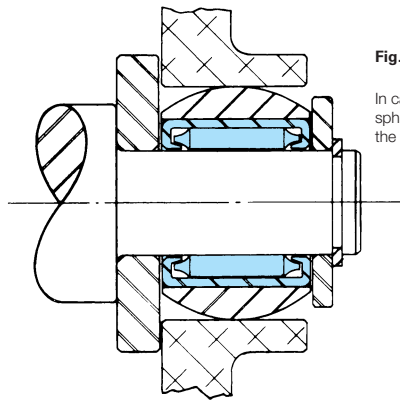
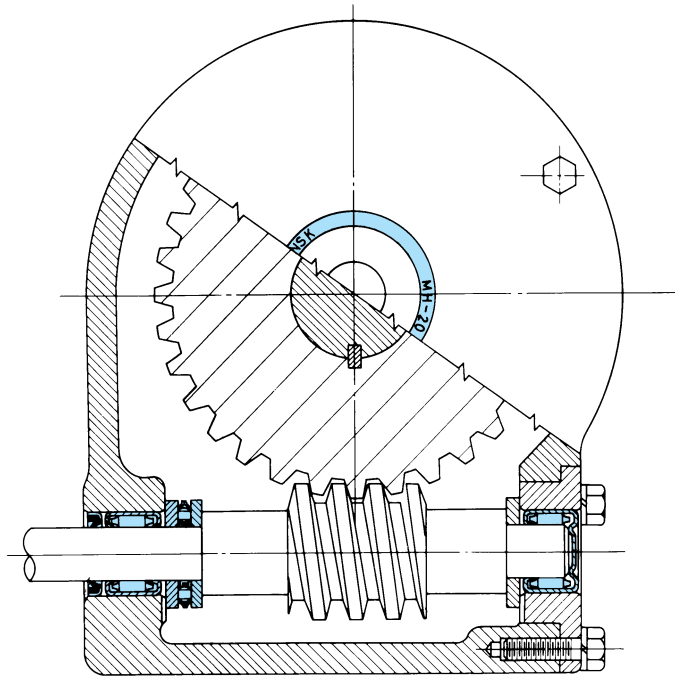


Fig. 53 Copying Machine Paper Feed Mechanism

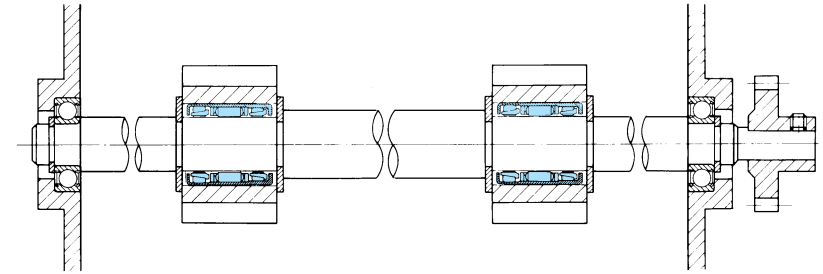


**Fig. 54 Copying Machine Side Frame  
(In Case of Frequent Misalignment)**

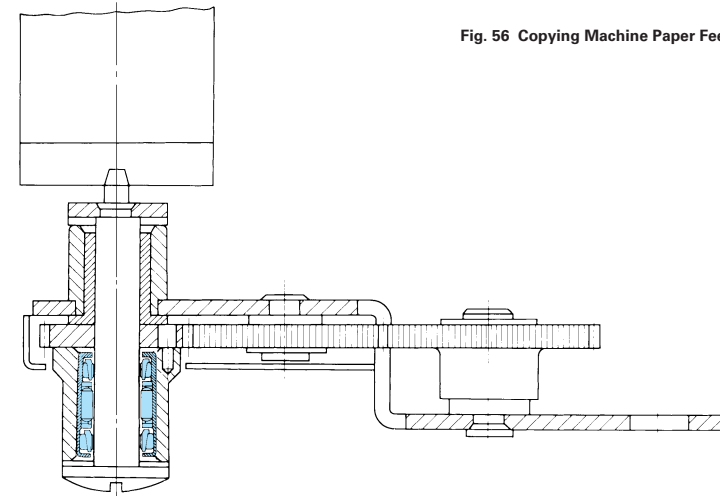
In case misalignment cannot be avoided, the spherical housing may be used as shown in the figure.



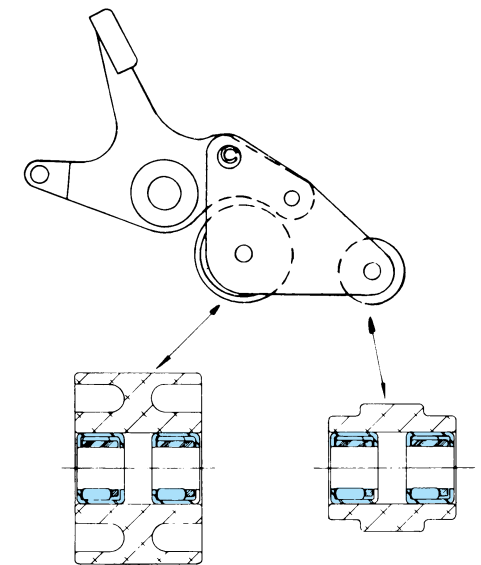
**Fig. 55 Speed Reducer for Business Machines**



**Fig. 56 Copying Machine Paper Feed Roll**

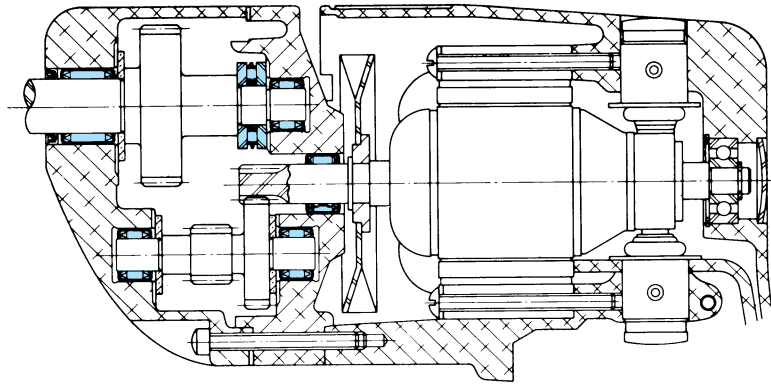


**Fig. 57 Copying Machine  
Paper Feed Roll Mechanism**



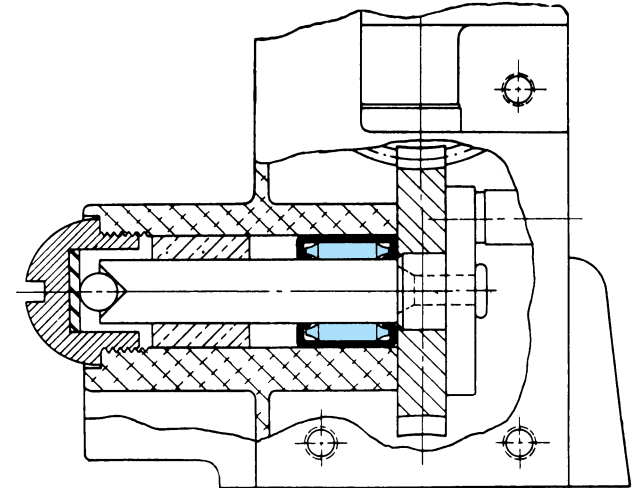
**Fig. 58 Copying Machine Drive Roll (With Small Roll Diameter)**

ELECTRIC AND PNEUMATIC EQUIPMENT



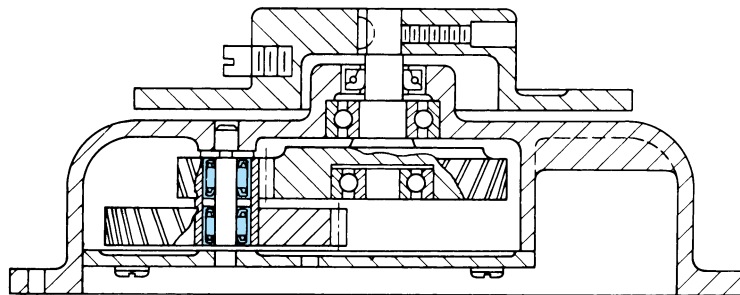
**Fig. 59 Electric Drill**

The application of a drawn cup needle roller bearing contributes to shortening the distance between shafts and reduces size and weight.  
A needle roller bearing with a cage is applied to the motor shaft due to high-speed rotation.

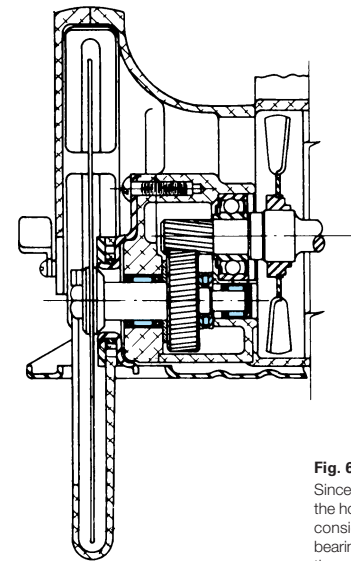


**Fig. 61 Hedge Trimmer**

The figure shows the crankshaft of a hedge trimmer. A hardened steel ball is used as the center shaft because an axial load through worm gears is imposed there.



**Fig. 60 Electric Polisher**



**Fig. 62 Circular Saw**

Since ball bearings are commonly applied to motor fan shafts, the housing space on the right-hand side of the spindle shaft is considerably limited. Accordingly, drawn cup needle roller bearings are used in many cases. In order to prevent grease in the gearbox from entering into the motor, a closed type bearing is applied.

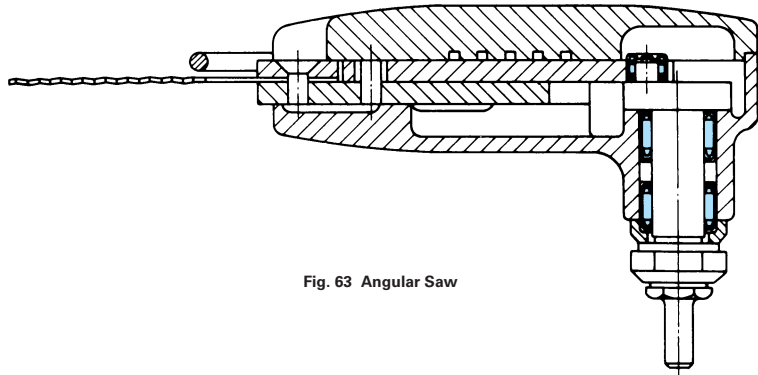


Fig. 63 Angular Saw

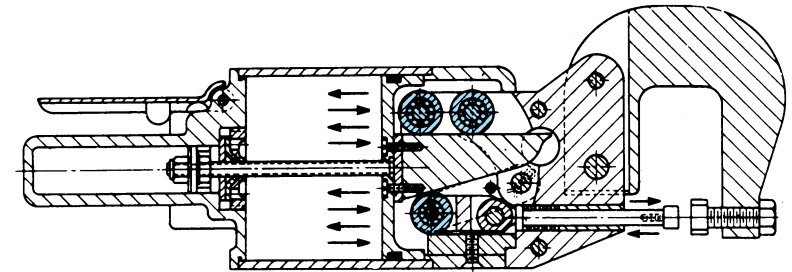


Fig. 65 Rivetter

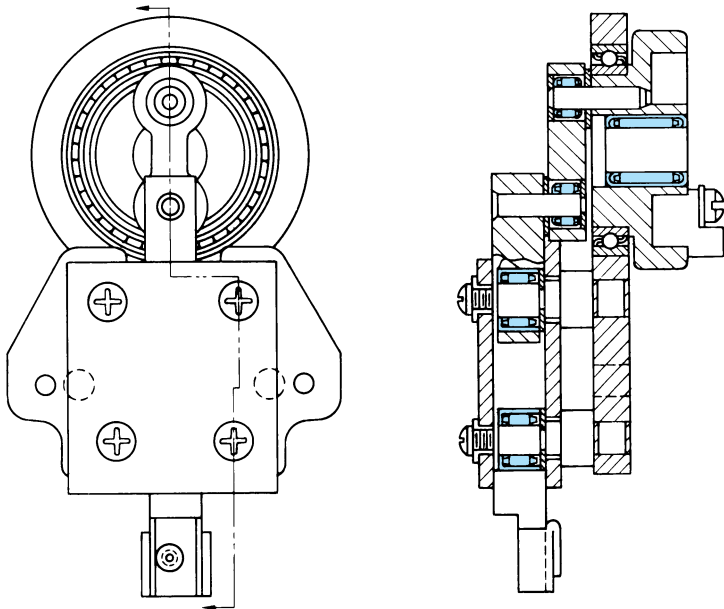


Fig. 64 Shaper Saw

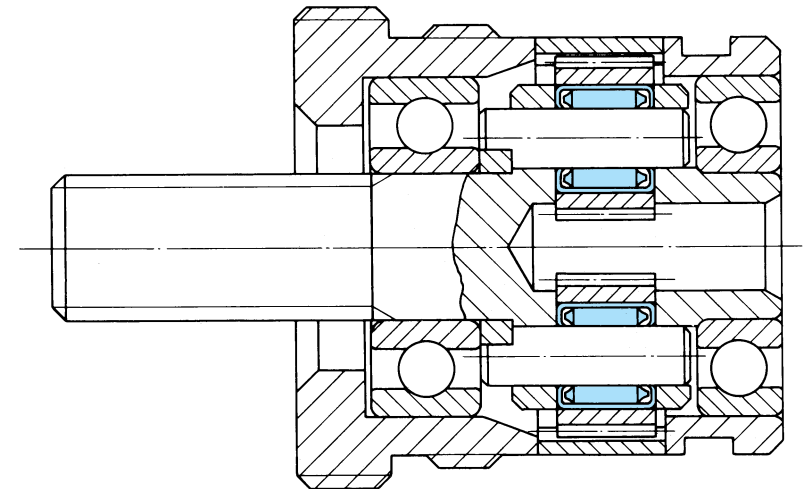
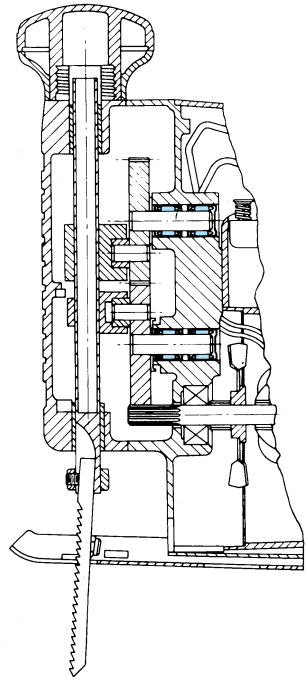
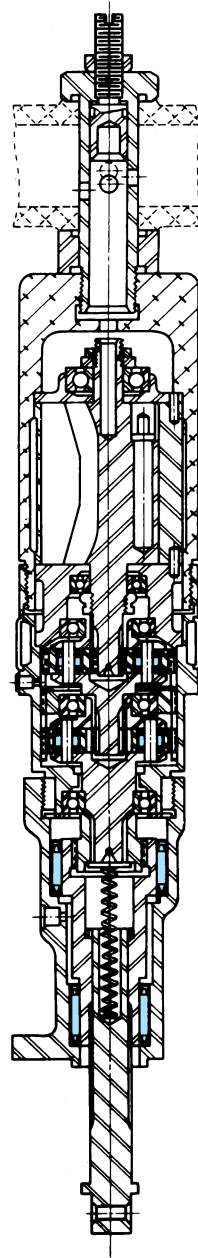


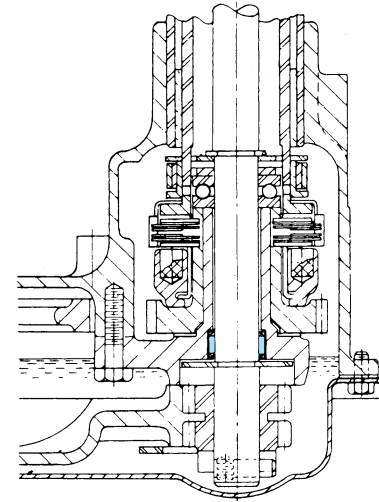
Fig. 66 Planetary Gears of Air Drill



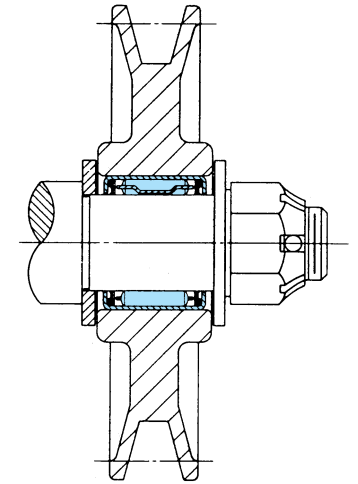
**Fig. 67 Jig Saw**  
Two drawn cup needle roller bearings are applied to support the blade and counter balance driving gears.



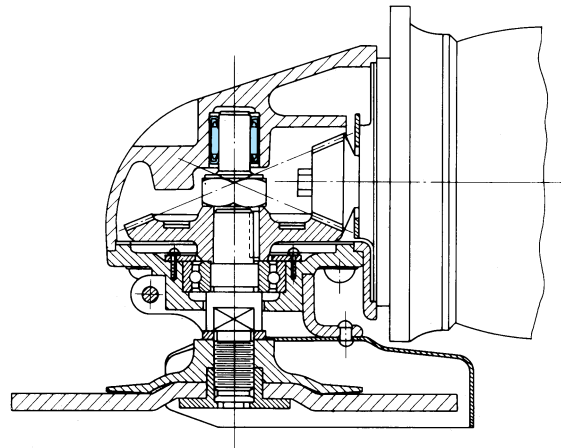
**Fig. 69 Nut Setter**



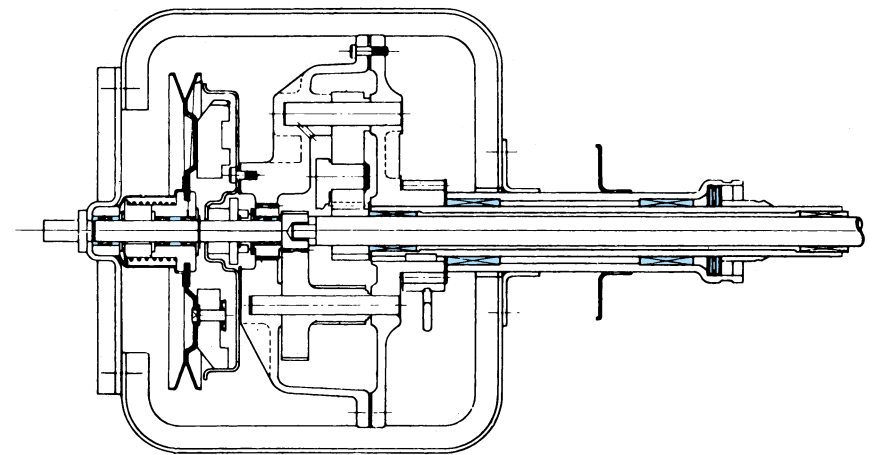
**Fig. 70 Agitator Shaft**



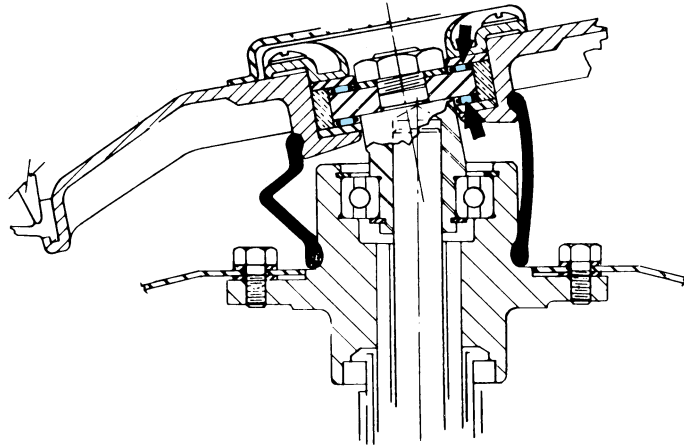
**Fig. 71 Pulley Support**  
This is a good example of low-cost design, showing that a single drawn cup needle roller bearing with a seal can deliver stable performance without maintenance over a long period of time to facilitate long life.



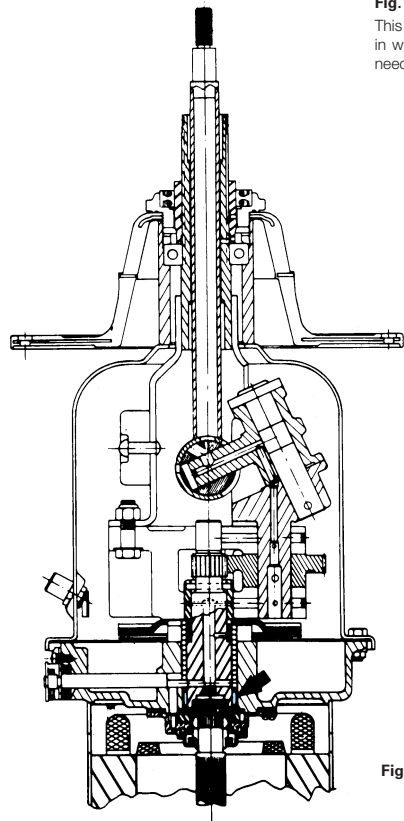
**Fig. 68 Polisher**  
It is possible to use the housing as a through hole by changing the drawn cup needle roller bearing on the upper part of the spindle shaft to a closed type.



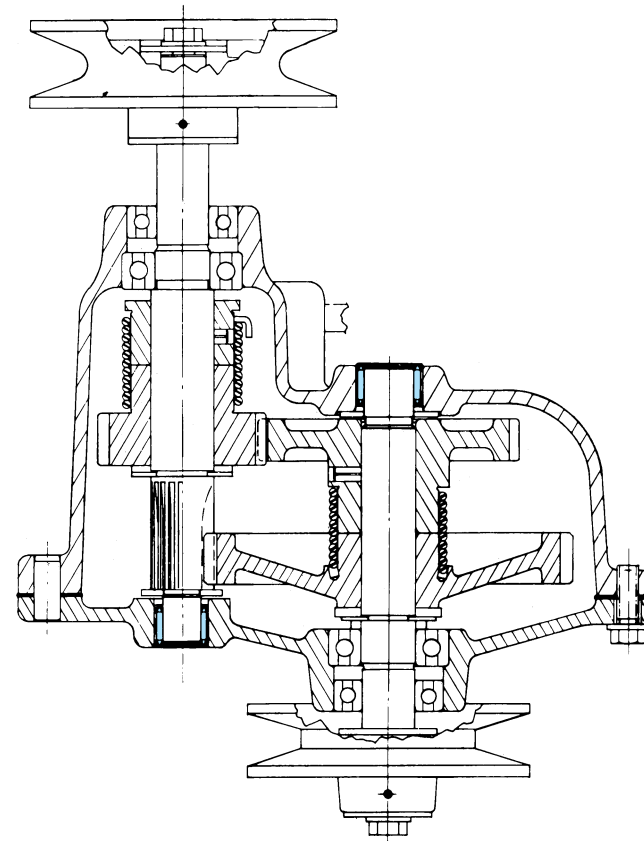
**Fig. 72 Agitator Shaft**



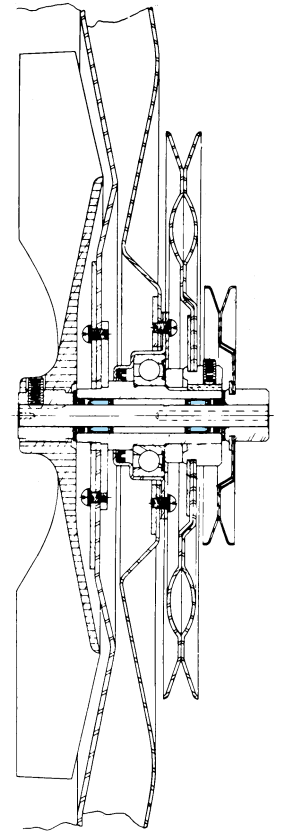
**Fig. 73 Spank Mechanism**  
 This is a typical example of a vertical agitator in which a ball bearing was replaced with a needle roller bearing to reduce size.



**Fig. 74 Spank Agitator**



**Fig. 76 Washer and Dryer Two-Speed Transmission**



**Fig. 75 Washer and Dryer Fan-Drive Pulley**

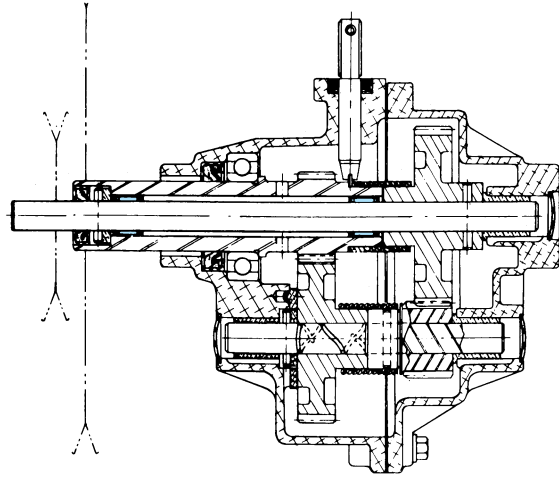


Fig. 77 Washer and Dryer Two-Speed Transmission

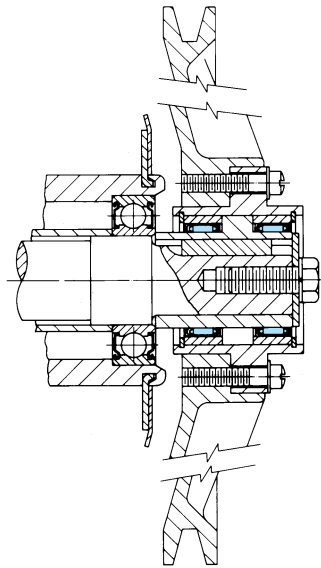


Fig. 78 Washing Machine Basket Drive Shaft

TWO-STROKE ENGINES

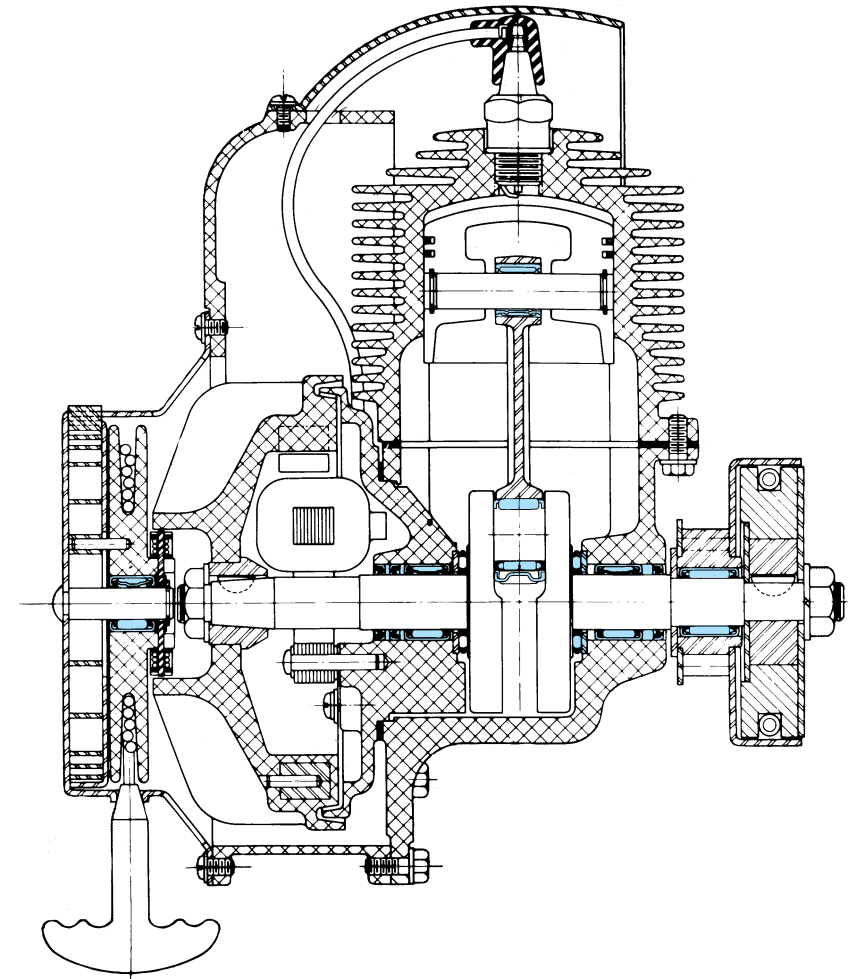
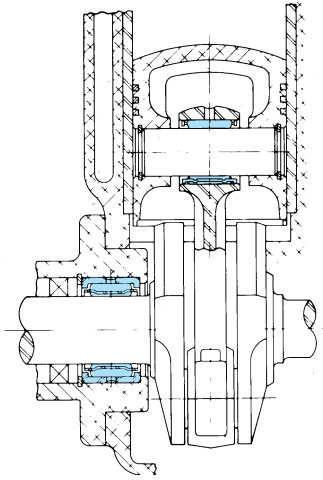


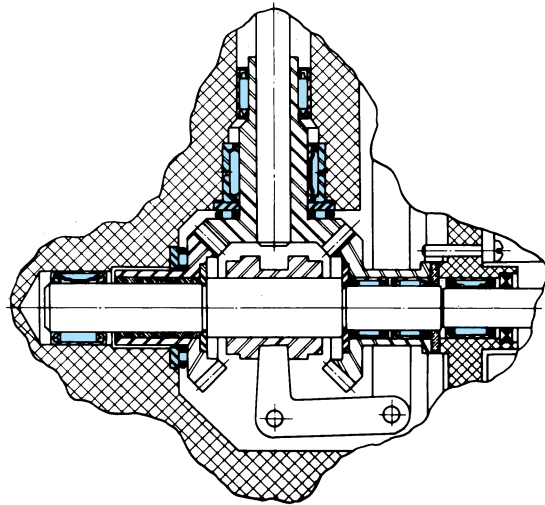
Fig. 79 Chain Saw Engine

Many drawn cup needle roller bearings are applied to the chain saw engine, contributing to its lighter weight. Application of a drawn cup roller clutch to the starter allows further simplification of operation.



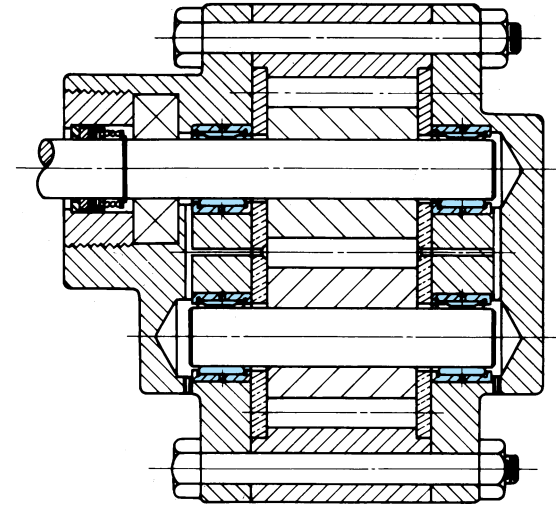


**Fig. 80 Two-Stroke Engine**  
 This illustrates the application of a solid needle roller bearing to the crankshaft, increasing load capacity and facilitating a more compact size.

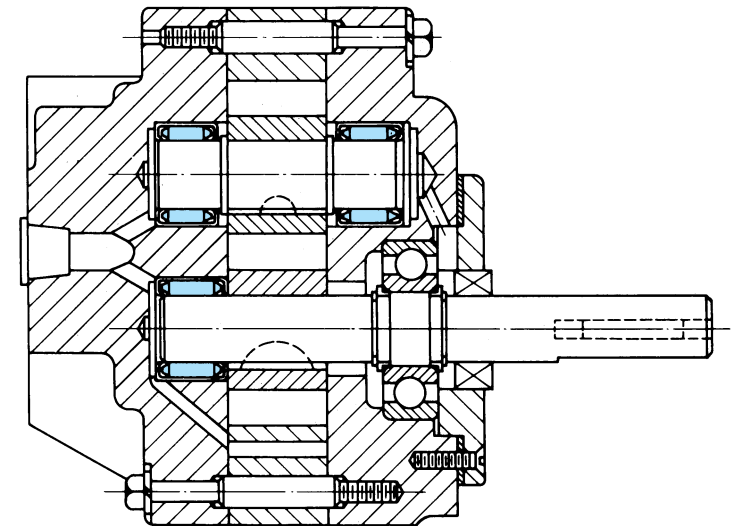


**Fig. 81 Outboard Motor Lower Unit**

HYDRAULIC MACHINES



**Fig. 82 Gear Pump**  
 A solid needle roller bearing is commonly applied to high-pressure gear pumps. Since the load is large and problems such as edge load may be caused by shaft deflection, crowning should be applied to the rollers.



**Fig. 83 Gear Pump**  
 The comparatively low-pressure gear pump operates satisfactorily with a drawn cup needle roller bearing. It also serves to reduce cost.

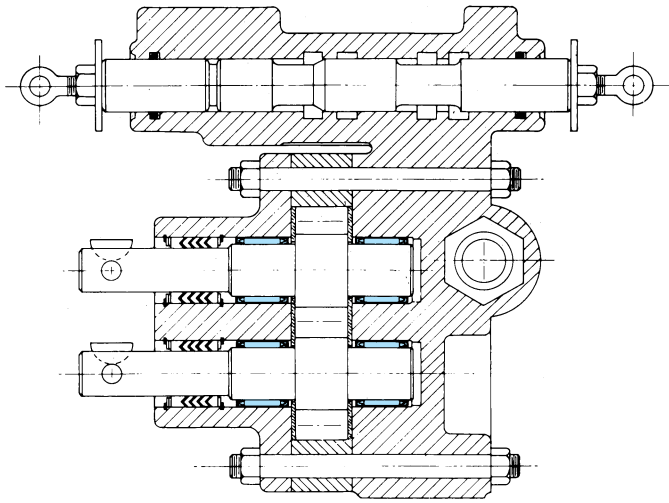


Fig. 84 Gear Pump

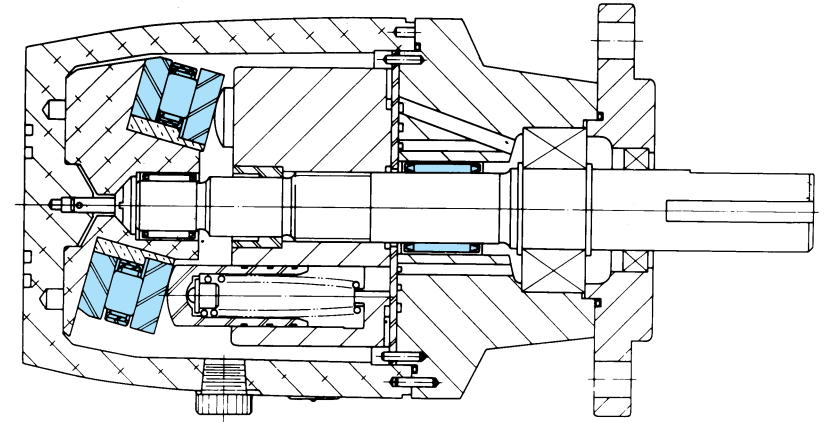


Fig. 86 Axial Piston Pump

For high-pressure axial piston pumps, NTH thrust roller bearings, which have a large load capacity, are recommended. Although this example uses a copper alloy bush for the bore diameter guide face of the thrust roller bearing, a bush would not be required should the guide face be hardened and ground to HRC58 or more.

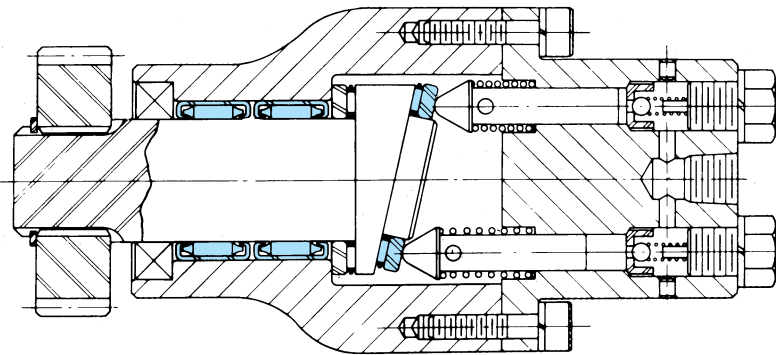


Fig. 85 Axial Piston Pump

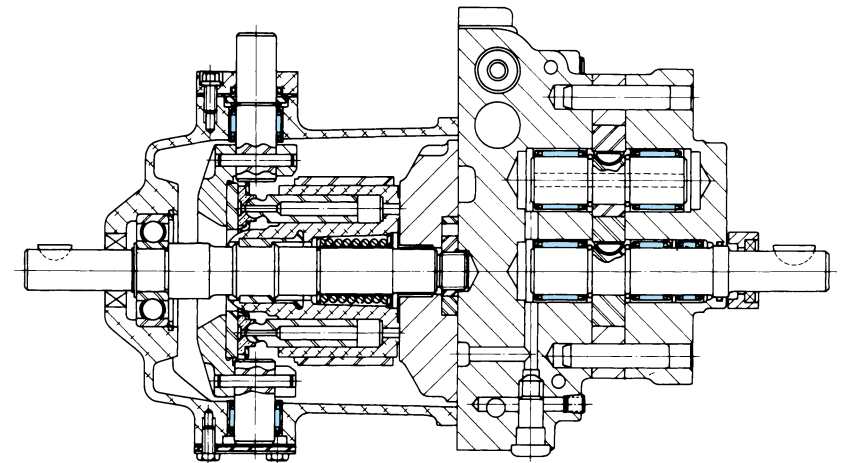
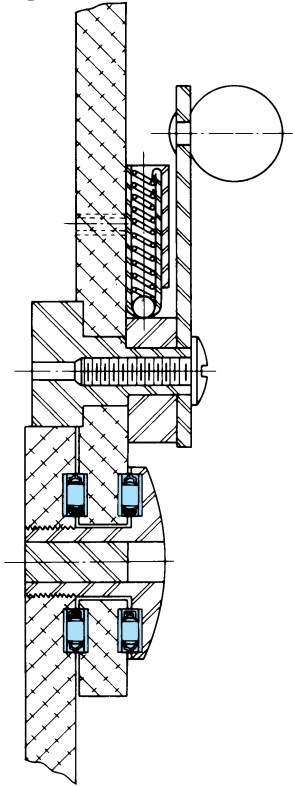


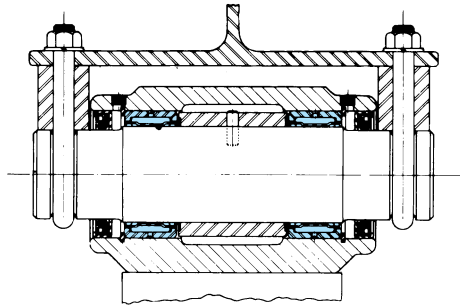
Fig. 87 Hydraulic Transmission

This illustrates a hydraulic transmission combining a variable displacement axial piston pump and a fixed displacement gear motor. A drawn cup needle roller bearing is applied to the pivoting portion and the gear motor of the rotating swash plate of the axial piston pump.

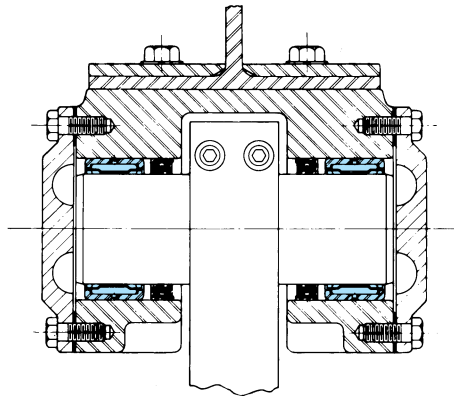
OTHERS



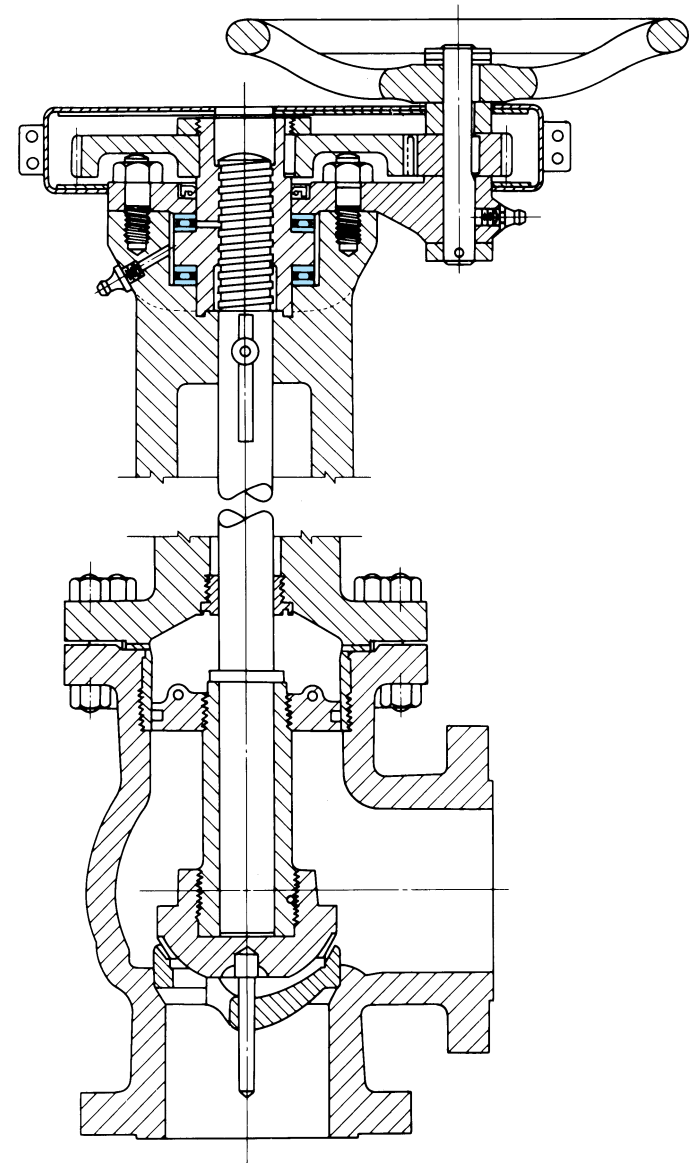
**Fig. 88 Magic Hand**  
The application of a thrust needle roller bearing to a magic hand or artificial arm facilitates smooth operation.



**Fig. 89 Oil Well Equipment (Pump Jack)**



**Fig. 90 Oil Well Equipment (Pump Jack)**



**Fig. 91 Valve**

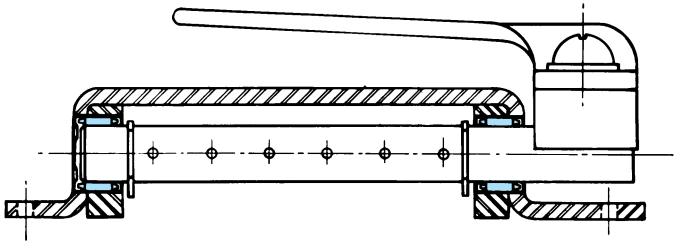


Fig. 92 Electric Guitar Tremolo

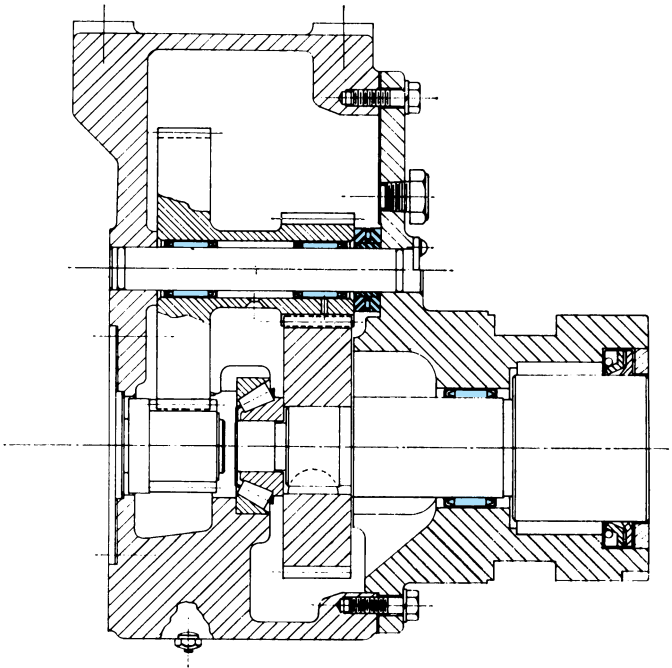


Fig. 93 Meat Saw for Hamburgers

Appendix 1 Conversion Table from SI (International Units) System

Comparison of SI, CGS, and Engineering Units

Units Unit System	Length	Mass	Time	Temp.	Accelera- tion	Force	Stress	Pressure	Energy	Power
SI	m	kg	s	K, °C	m/s <sup>2</sup>	N	Pa	Pa	J	W
CGS System	cm	g	s	°C	Gal	dyn	dyn/cm <sup>2</sup>	dyn/cm <sup>2</sup>	erg	erg/s
Engineering Unit System	m	kgf·s <sup>2</sup> /m	s	°C	m/s <sup>2</sup>	kgf	kgf/m <sup>2</sup>	kgf/m <sup>2</sup>	kgf·m	kgf·m/s

Conversion Factors from SI Units

Parameter	SI Units		Units other than SI		Conversion Factors from SI Units
	Names of Units	Symbols	Names of Units	Symbols	
Angle	Radian	rad	Degree Minute Second	° ' "	180/π 10 800/π 648 000/π
Length	Meter	m	Micron Angstrom	μ Å	10 <sup>6</sup> 10 <sup>10</sup>
Area	Square meter	m <sup>2</sup>	Are Hectare	a ha	10 <sup>-2</sup> 10 <sup>-4</sup>
Volume	Cubic meter	m <sup>3</sup>	Liter Deciliter	l, L dl, dL	10 <sup>3</sup> 10 <sup>4</sup>
Time	Second	s	Minute Hour Day	min h d	1/60 1/3 600 1/86 400
Frequency	Hertz	Hz	Cycle	s <sup>-1</sup>	1
Speed of Rotation	Revolution per second	s <sup>-1</sup>	Revolution per minute	rpm	60
Speed	Meter per second	m/s	Kilometer per hour Knot	km/h kn	3 600/1 000 3 600/1 852
Acceleration	Meter per second per second	m/s <sup>2</sup>	Gal g	Gal g	10 <sup>2</sup> 1/9.806 65
Mass	Kilogram	kg	Ton	t	10 <sup>-3</sup>
Force	Newton	N	Kilogram-force Ton-force Dyne	kgf tf dyn	1/9.806 65 1/(9.806 65 × 10 <sup>3</sup> ) 10 <sup>5</sup>
Torque or Moment	Newton·meter	N·m	Kilogram-force meter	kgf·m	1/9.806 65
Stress	Pascal	Pa (N/m <sup>2</sup> )	Kilogram-force per square centimeter Kilogram-force per square millimeter	kgf/cm <sup>2</sup> kgf/mm <sup>2</sup>	1/(9.806 65 × 10 <sup>4</sup> ) 1/(9.806 65 × 10 <sup>6</sup> )

Prefixes Used In SI System

Multiples	Prefix	Symbols	Multiples	Prefix	Symbols
10 <sup>18</sup>	Exa	E	10 <sup>-1</sup>	Deci	d
10 <sup>15</sup>	Peta	P	10 <sup>-2</sup>	Centi	c
10 <sup>12</sup>	Tera	T	10 <sup>-3</sup>	Milli	m
10 <sup>9</sup>	Giga	G	10 <sup>-6</sup>	Micro	μ
10 <sup>6</sup>	Mega	M	10 <sup>-9</sup>	Nano	n
10 <sup>3</sup>	Kilo	k	10 <sup>-12</sup>	Pico	p
10 <sup>2</sup>	Hecto	h	10 <sup>-15</sup>	Femto	f
10	Deca	da	10 <sup>-18</sup>	Ato	a

Conversion Factors from SI Units (Continued)

Parameter	SI Units		Units other than SI		Conversion Factors from SI Units
	Names of Units	Symbols	Names of Units	Symbols	
Pressure	Pascal (Newton per square meter)	Pa (N/m <sup>2</sup> )	Kilogram-force per square meter Water Column Mercury Column Torr Bar Atmosphere	kgf/m <sup>2</sup> mH <sub>2</sub> O mmHg Torr bar atm	1/9.806 65 1/(9.806 65 × 10 <sup>3</sup> ) 760/(1.013 25 × 10 <sup>5</sup> ) 760/(1.013 25 × 10 <sup>5</sup> ) 10 <sup>-5</sup> 1/(1.013 25 × 10 <sup>5</sup> )
Energy	Joule (Newton-meter)	J (N·m)	Erg Calorie (International) Kilogram-force meter Kilowatt hour French horse power hour	erg cal <sub>IT</sub> kgf·m kW·h PS·h	10 <sup>7</sup> 1/4.186 8 1/9.806 65 1/(3.6 × 10 <sup>6</sup> ) ≈ 3.776 72 × 10 <sup>-7</sup>
Work	Watt (Joule per second)	W (J/s)	Kilogram-force meter per second Kilocalorie per hour French horse power	kgf·m/s kcal/h PS	1/9.806 65 1/1.163 ≈ 1/735.498 8
Viscosity, Viscosity Index	Pascal second	Pa·s	Poise	P	10
Kinematic Viscosity, Kinematic Viscosity Index	Square meter per second	m <sup>2</sup> /s	Stokes Centistokes	St cSt	10 <sup>4</sup> 10 <sup>6</sup>
Temperature	Kelvin, Degree Celsius	K, °C	Degree,	°C	(See Note (1))
Electric Current, Magnetomotive Force	Ampere	A	Ampere	A	1
Voltage, Electromotive Force	Volt	V	(Watts per ampere)	(W/A)	1
Magnetic Field Strength	Ampere per meter	A/m	Oersted	Oe	4π/10 <sup>3</sup>
Magnetic Flux Density	Tesla	T	Gauss Gamma	Gs γ	10 <sup>4</sup> 10 <sup>9</sup>
Electrical Resistance	Ohm	Ω	(Volts per ampere)	(V/A)	1

**Note (1)** The conversion from TK into θ °C is θ = T-273.15 but for a temperature difference, it is ΔT = Δθ. However, ΔT and Δθ represent temperature differences measured using the Kelvin and Celsius scales respectively.

**Remarks** The names and symbols in ( ) are equivalent to those directly above them or on their left. Example of conversion 1 N = 1/9.806 65 kgf

Appendix 2 N-kgf Conversion Table

(Method of using this table) For example, to convert 10N into kgf, read the figure in the right kgf column adjacent to the 10 in the center column in the 1st block. This means that 10N is 1.0197kgf. To convert 10kgf into N, read the figure in the left N column of the same row, which indicates that the answer is 98.066N.

1 N=0.1019716 kgf  
1 kgf=9.80665 N

N		kgf	N		kgf	N		kgf
9.8066	<b>1</b>	0.1020	333.43	<b>34</b>	3.4670	657.05	<b>67</b>	6.8321
19.613	<b>2</b>	0.2039	343.23	<b>35</b>	3.5690	666.85	<b>68</b>	6.9341
29.420	<b>3</b>	0.3059	353.04	<b>36</b>	3.6710	676.66	<b>69</b>	7.0360
39.227	<b>4</b>	0.4079	362.85	<b>37</b>	3.7729	686.47	<b>70</b>	7.1380
49.033	<b>5</b>	0.5099	372.65	<b>38</b>	3.8749	696.27	<b>71</b>	7.2400
58.840	<b>6</b>	0.6118	382.46	<b>39</b>	3.9769	706.08	<b>72</b>	7.3420
68.647	<b>7</b>	0.7138	392.27	<b>40</b>	4.0789	715.89	<b>73</b>	7.4439
78.453	<b>8</b>	0.8158	402.07	<b>41</b>	4.1808	725.69	<b>74</b>	7.5459
88.260	<b>9</b>	0.9177	411.88	<b>42</b>	4.2828	735.50	<b>75</b>	7.6479
98.066	<b>10</b>	1.0197	421.69	<b>43</b>	4.3848	745.31	<b>76</b>	7.7498
107.87	<b>11</b>	1.1217	431.49	<b>44</b>	4.4868	755.11	<b>77</b>	7.8518
117.68	<b>12</b>	1.2237	441.30	<b>45</b>	4.5887	764.92	<b>78</b>	7.9538
127.49	<b>13</b>	1.3256	451.11	<b>46</b>	4.6907	774.73	<b>79</b>	8.0558
137.29	<b>14</b>	1.4276	460.91	<b>47</b>	4.7927	784.53	<b>80</b>	8.1577
147.10	<b>15</b>	1.5296	470.72	<b>48</b>	4.8946	794.34	<b>81</b>	8.2597
156.91	<b>16</b>	1.6315	480.53	<b>49</b>	4.9966	804.15	<b>82</b>	8.3617
166.71	<b>17</b>	1.7335	490.33	<b>50</b>	5.0986	813.95	<b>83</b>	8.4636
176.52	<b>18</b>	1.8355	500.14	<b>51</b>	5.2006	823.76	<b>84</b>	8.5656
186.33	<b>19</b>	1.9375	509.95	<b>52</b>	5.3025	833.57	<b>85</b>	8.6676
196.13	<b>20</b>	2.0394	519.75	<b>53</b>	5.4045	843.37	<b>86</b>	8.7696
205.94	<b>21</b>	2.1414	529.56	<b>54</b>	5.5065	853.18	<b>87</b>	8.8715
215.75	<b>22</b>	2.2434	539.37	<b>55</b>	5.6084	862.99	<b>88</b>	8.9735
225.55	<b>23</b>	2.3453	549.17	<b>56</b>	5.7104	872.79	<b>89</b>	9.0755
235.36	<b>24</b>	2.4473	558.98	<b>57</b>	5.8124	882.60	<b>90</b>	9.1774
245.17	<b>25</b>	2.5493	568.79	<b>58</b>	5.9144	892.41	<b>91</b>	9.2794
254.97	<b>26</b>	2.6513	578.59	<b>59</b>	6.0163	902.21	<b>92</b>	9.3814
264.78	<b>27</b>	2.7532	588.40	<b>60</b>	6.1183	912.02	<b>93</b>	9.4834
274.59	<b>28</b>	2.8552	598.21	<b>61</b>	6.2203	921.83	<b>94</b>	9.5853
284.39	<b>29</b>	2.9572	608.01	<b>62</b>	6.3222	931.63	<b>95</b>	9.6873
294.20	<b>30</b>	3.0591	617.82	<b>63</b>	6.4242	941.44	<b>96</b>	9.7893
304.01	<b>31</b>	3.1611	627.63	<b>64</b>	6.5262	951.25	<b>97</b>	9.8912
313.81	<b>32</b>	3.2631	637.43	<b>65</b>	6.6282	961.05	<b>98</b>	9.9932
323.62	<b>33</b>	3.3651	647.24	<b>66</b>	6.7301	970.86	<b>99</b>	10.095

Appendix 3 kg-lb Conversion Table

(Method of using this table) For example, to convert 10kg into lb, read the figure in the right lb column adjacent to the 10 in the center column in the 1st block. This means that 10kg is 22.046lb. To convert 10lb into kg, read the figure in the left kg column of the same row, which indicates that the answer is 4.536kg.

1 kg=2.2046226 lb  
1 lb=0.45359237 kg

kg		lb	kg		lb	kg		lb
0.454	<b>1</b>	2.205	15.422	<b>34</b>	74.957	30.391	<b>67</b>	147.71
0.907	<b>2</b>	4.409	15.876	<b>35</b>	77.162	30.844	<b>68</b>	149.91
1.361	<b>3</b>	6.614	16.329	<b>36</b>	79.366	31.298	<b>69</b>	152.12
1.814	<b>4</b>	8.818	16.783	<b>37</b>	81.571	31.751	<b>70</b>	154.32
2.268	<b>5</b>	11.023	17.237	<b>38</b>	83.776	32.205	<b>71</b>	156.53
2.722	<b>6</b>	13.228	17.690	<b>39</b>	85.980	32.659	<b>72</b>	158.73
3.175	<b>7</b>	15.432	18.144	<b>40</b>	88.185	33.112	<b>73</b>	160.94
3.629	<b>8</b>	17.637	18.597	<b>41</b>	90.390	33.566	<b>74</b>	163.14
4.082	<b>9</b>	19.842	19.051	<b>42</b>	92.594	34.019	<b>75</b>	165.35
4.536	<b>10</b>	22.046	19.504	<b>43</b>	94.799	34.473	<b>76</b>	167.55
4.990	<b>11</b>	24.251	19.958	<b>44</b>	97.003	34.927	<b>77</b>	169.76
5.443	<b>12</b>	26.455	20.412	<b>45</b>	99.208	35.380	<b>78</b>	171.96
5.897	<b>13</b>	28.660	20.865	<b>46</b>	101.41	35.834	<b>79</b>	174.17
6.350	<b>14</b>	30.865	21.319	<b>47</b>	103.62	36.287	<b>80</b>	176.37
6.804	<b>15</b>	33.069	21.772	<b>48</b>	105.82	36.741	<b>81</b>	178.57
7.257	<b>16</b>	35.274	22.226	<b>49</b>	108.03	37.195	<b>82</b>	180.78
7.711	<b>17</b>	37.479	22.680	<b>50</b>	110.23	37.648	<b>83</b>	182.98
8.165	<b>18</b>	39.683	23.133	<b>51</b>	112.44	38.102	<b>84</b>	185.19
8.618	<b>19</b>	41.888	23.587	<b>52</b>	114.64	38.555	<b>85</b>	187.39
9.072	<b>20</b>	44.092	24.040	<b>53</b>	116.84	39.009	<b>86</b>	189.60
9.525	<b>21</b>	46.297	24.494	<b>54</b>	119.05	39.463	<b>87</b>	191.80
9.979	<b>22</b>	48.502	24.948	<b>55</b>	121.25	39.916	<b>88</b>	194.01
10.433	<b>23</b>	50.706	25.401	<b>56</b>	123.46	40.370	<b>89</b>	196.21
10.886	<b>24</b>	52.911	25.855	<b>57</b>	125.66	40.823	<b>90</b>	198.42
11.340	<b>25</b>	55.116	26.308	<b>58</b>	127.87	41.277	<b>91</b>	200.62
11.793	<b>26</b>	57.320	26.762	<b>59</b>	130.07	41.730	<b>92</b>	202.83
12.247	<b>27</b>	59.525	27.216	<b>60</b>	132.28	42.184	<b>93</b>	205.03
12.701	<b>28</b>	61.729	27.669	<b>61</b>	134.48	42.638	<b>94</b>	207.23
13.154	<b>29</b>	63.934	28.123	<b>62</b>	136.69	43.091	<b>95</b>	209.44
13.608	<b>30</b>	66.139	28.576	<b>63</b>	138.89	43.545	<b>96</b>	211.64
14.061	<b>31</b>	68.343	29.030	<b>64</b>	141.10	43.998	<b>97</b>	213.85
14.515	<b>32</b>	70.548	29.484	<b>65</b>	143.30	44.452	<b>98</b>	216.05
14.969	<b>33</b>	72.753	29.937	<b>66</b>	145.51	44.906	<b>99</b>	218.26

Appendix 4 °C-°F Conversion Table

(Method of using this table)

For example, to convert 38°C into °F, read the figure in the right °F column adjacent to the 38 in the center column in the 2nd block. This means that 38°C is 100.4°F. To convert 38°F into °C, read the figure in the left °C column of the same row, which indicates that the answer is 3.3°C.

$$C = \frac{5}{9}(F - 32)$$

$$F = 32 + \frac{9}{5}C$$

°C	°F		°C	°F		°C	°F		°C	°F	
	Left	Right		Left	Right		Left	Right		Left	Right
-73.3	<b>100</b>	-148.0	0.0	<b>32</b>	89.6	21.7	<b>71</b>	159.8	43.3	<b>110</b>	230
-62.2	<b>80</b>	-112.0	0.6	<b>33</b>	91.4	22.2	<b>72</b>	161.6	46.1	<b>115</b>	239
-51.1	<b>60</b>	-76.0	1.1	<b>34</b>	93.2	22.8	<b>73</b>	163.4	48.9	<b>120</b>	248
-40.0	<b>40</b>	-40.0	1.7	<b>35</b>	95.0	23.3	<b>74</b>	165.2	51.7	<b>125</b>	257
-34.4	<b>30</b>	-22.0	2.2	<b>36</b>	96.8	23.9	<b>75</b>	167.0	54.4	<b>130</b>	266
-28.9	<b>20</b>	-4.0	2.8	<b>37</b>	98.6	24.4	<b>76</b>	168.8	57.2	<b>135</b>	275
-23.3	<b>10</b>	14.0	3.3	<b>38</b>	100.4	25.0	<b>77</b>	170.6	60.0	<b>140</b>	284
-17.8	<b>0</b>	32.0	3.9	<b>39</b>	102.2	25.6	<b>78</b>	172.4	65.6	<b>150</b>	302
-17.2	<b>1</b>	33.8	4.4	<b>40</b>	104.0	26.1	<b>79</b>	174.2	71.1	<b>160</b>	320
-16.7	<b>2</b>	35.6	5.0	<b>41</b>	105.8	26.7	<b>80</b>	176.0	76.7	<b>170</b>	338
-16.1	<b>3</b>	37.4	5.6	<b>42</b>	107.6	27.2	<b>81</b>	177.8	82.2	<b>180</b>	356
-15.6	<b>4</b>	39.2	6.1	<b>43</b>	109.4	27.8	<b>82</b>	179.6	87.8	<b>190</b>	374
-15.0	<b>5</b>	41.0	6.7	<b>44</b>	111.2	28.3	<b>83</b>	181.4	93.3	<b>200</b>	392
-14.4	<b>6</b>	42.8	7.2	<b>45</b>	113.0	28.9	<b>84</b>	183.2	98.9	<b>210</b>	410
-13.9	<b>7</b>	44.6	7.8	<b>46</b>	114.8	29.4	<b>85</b>	185.0	104.4	<b>220</b>	428
-13.3	<b>8</b>	46.4	8.3	<b>47</b>	116.6	30.0	<b>86</b>	186.8	110.0	<b>230</b>	446
-12.8	<b>9</b>	48.2	8.9	<b>48</b>	118.4	30.6	<b>87</b>	188.6	115.6	<b>240</b>	464
-12.2	<b>10</b>	50.0	9.4	<b>49</b>	120.2	31.1	<b>88</b>	190.4	121.1	<b>250</b>	482
-11.7	<b>11</b>	51.8	10.0	<b>50</b>	122.0	31.7	<b>89</b>	192.2	148.9	<b>300</b>	572
-11.1	<b>12</b>	53.6	10.6	<b>51</b>	123.8	32.2	<b>90</b>	194.0	176.7	<b>350</b>	662
-10.6	<b>13</b>	55.4	11.1	<b>52</b>	125.6	32.8	<b>91</b>	195.8	204	<b>400</b>	752
-10.0	<b>14</b>	57.2	11.7	<b>53</b>	127.4	33.3	<b>92</b>	197.6	232	<b>450</b>	842
-9.4	<b>15</b>	59.0	12.2	<b>54</b>	129.2	33.9	<b>93</b>	199.4	260	<b>500</b>	932
-8.9	<b>16</b>	60.8	12.8	<b>55</b>	131.0	34.4	<b>94</b>	201.2	288	<b>550</b>	1022
-8.3	<b>17</b>	62.6	13.3	<b>56</b>	132.8	35.0	<b>95</b>	203.0	316	<b>600</b>	1112
-7.8	<b>18</b>	64.4	13.9	<b>57</b>	134.6	35.6	<b>96</b>	204.8	343	<b>650</b>	1202
-7.2	<b>19</b>	66.2	14.4	<b>58</b>	136.4	36.1	<b>97</b>	206.6	371	<b>700</b>	1292
-6.7	<b>20</b>	68.0	15.0	<b>59</b>	138.2	36.7	<b>98</b>	208.4	399	<b>750</b>	1382
-6.1	<b>21</b>	69.8	15.6	<b>60</b>	140.0	37.2	<b>99</b>	210.2	427	<b>800</b>	1472
-5.6	<b>22</b>	71.6	16.1	<b>61</b>	141.8	37.8	<b>100</b>	212.0	454	<b>850</b>	1562
-5.0	<b>23</b>	73.4	16.7	<b>62</b>	143.6	38.3	<b>101</b>	213.8	482	<b>900</b>	1652
-4.4	<b>24</b>	75.2	17.2	<b>63</b>	145.4	38.9	<b>102</b>	215.6	510	<b>950</b>	1742
-3.9	<b>25</b>	77.0	17.8	<b>64</b>	147.2	39.4	<b>103</b>	217.4	538	<b>1 000</b>	1832
-3.3	<b>26</b>	78.8	18.3	<b>65</b>	149.0	40.0	<b>104</b>	219.2	593	<b>1 100</b>	2012
-2.8	<b>27</b>	80.6	18.9	<b>66</b>	150.8	40.6	<b>105</b>	221.0	649	<b>1 200</b>	2192
-2.2	<b>28</b>	82.4	19.4	<b>67</b>	152.6	41.1	<b>106</b>	222.8	704	<b>1 300</b>	2372
-1.7	<b>29</b>	84.2	20.0	<b>68</b>	154.4	41.7	<b>107</b>	224.6	760	<b>1 400</b>	2552
-1.1	<b>30</b>	86.0	20.6	<b>69</b>	156.2	42.2	<b>108</b>	226.4	816	<b>1 500</b>	2732
-0.6	<b>31</b>	87.8	21.1	<b>70</b>	158.0	42.8	<b>109</b>	228.2	871	<b>1 600</b>	2912

Appendix 5 Viscosity Conversion Table

Kinematic Viscosity mm <sup>2</sup> /s	Saybolt Universal SUS (sec)		No.1 Type Redwood R (sec)		Engler E (degree)	Kinematic Viscosity mm <sup>2</sup> /s	Saybolt Universal SUS (sec)		No.1 Type Redwood R (sec)		Engler E (degree)
	100°F	210°F	50°C	100°C			100°F	210°F	50°C	100°C	
<b>2</b>	32.6	32.8	30.8	31.2	1.14	<b>35</b>	163	164	144	147	4.70
<b>3</b>	36.0	36.3	33.3	33.7	1.22	<b>36</b>	168	170	148	151	4.83
<b>4</b>	39.1	39.4	35.9	36.5	1.31	<b>37</b>	172	173	153	155	4.96
<b>5</b>	42.3	42.6	38.5	39.1	1.40	<b>38</b>	177	178	156	159	5.08
<b>6</b>	45.5	45.8	41.1	41.7	1.48	<b>39</b>	181	183	160	164	5.21
<b>7</b>	48.7	49.0	43.7	44.3	1.56	<b>40</b>	186	187	164	168	5.34
<b>8</b>	52.0	52.4	46.3	47.0	1.65	<b>41</b>	190	192	168	172	5.47
<b>9</b>	55.4	55.8	49.1	50.0	1.75	<b>42</b>	195	196	172	176	5.59
<b>10</b>	58.8	59.2	52.1	52.9	1.84	<b>43</b>	199	201	176	180	5.72
<b>11</b>	62.3	62.7	55.1	56.0	1.93	<b>44</b>	204	205	180	185	5.85
<b>12</b>	65.9	66.4	58.2	59.1	2.02	<b>45</b>	208	210	184	189	5.98
<b>13</b>	69.6	70.1	61.4	62.3	2.12	<b>46</b>	213	215	188	193	6.11
<b>14</b>	73.4	73.9	64.7	65.6	2.22	<b>47</b>	218	219	193	197	6.24
<b>15</b>	77.2	77.7	68.0	69.1	2.32	<b>48</b>	222	224	197	202	6.37
<b>16</b>	81.1	81.7	71.5	72.6	2.43	<b>49</b>	227	228	201	206	6.50
<b>17</b>	85.1	85.7	75.0	76.1	2.54	<b>50</b>	231	233	205	210	6.63
<b>18</b>	89.2	89.8	78.6	79.7	2.64	<b>55</b>	254	256	225	231	7.24
<b>19</b>	93.3	94.0	82.1	83.6	2.76	<b>60</b>	277	279	245	252	7.90
<b>20</b>	97.5	98.2	85.8	87.4	2.87	<b>65</b>	300	302	266	273	8.55
<b>21</b>	102	102	89.5	91.3	2.98	<b>70</b>	323	326	286	294	9.21
<b>22</b>	106	107	93.3	95.1	3.10	<b>75</b>	346	349	306	315	9.89
<b>23</b>	110	111	97.1	98.9	3.22	<b>80</b>	371	373	326	336	10.5
<b>24</b>	115	115	101	103	3.34	<b>85</b>	394	397	347	357	11.2
<b>25</b>	119	120	105	107	3.46	<b>90</b>	417	420	367	378	11.8
<b>26</b>	123	124	109	111	3.58	<b>95</b>	440	443	387	399	12.5
<b>27</b>	128	129	112	115	3.70	<b>100</b>	464	467	408	420	13.2
<b>28</b>	132	133	116	119	3.82	<b>120</b>	556	560	490	504	15.8
<b>29</b>	137	138	120	123	3.95	<b>140</b>	649	653	571	588	18.4
<b>30</b>	141	142	124	127	4.07	<b>160</b>	742	747	653	672	21.1
<b>31</b>	145	146	128	131	4.20	<b>180</b>	834	840	734	757	23.7
<b>32</b>	150	150	132	135	4.32	<b>200</b>	927	933	816	841	26.3
<b>33</b>	154	155	136	139	4.45	<b>250</b>	1 159	1 167	1 020	1 051	32.9
<b>34</b>	159	160	140	143	4.57	<b>300</b>	1 391	1 400	1 224	1 241	39.5

Remarks 1mm<sup>2</sup>/s=1cSt

Appendix 6 inch-mm

inch		0	1	2	3	4	5	6
Fraction	Decimal	mm						
<b>0</b>	<b>0.000000</b>	<b>0.000</b>	<b>25.400</b>	<b>50.800</b>	<b>76.200</b>	<b>101.600</b>	<b>127.000</b>	<b>152.400</b>
1/64	0.015625	0.397	25.797	51.197	76.597	101.997	127.397	152.797
1/32	0.031250	0.794	26.194	51.594	76.994	102.394	127.794	153.194
3/64	0.046875	1.191	26.591	51.991	77.391	102.791	128.191	153.591
<b>1/16</b>	<b>0.062500</b>	<b>1.588</b>	<b>26.988</b>	<b>52.388</b>	<b>77.788</b>	<b>103.188</b>	<b>128.588</b>	<b>153.988</b>
5/64	0.078125	1.984	27.384	52.784	78.184	103.584	128.984	154.384
3/32	0.093750	2.381	27.781	53.181	78.581	103.981	129.381	154.781
7/64	0.109375	2.778	28.178	53.578	78.978	104.378	129.778	155.178
<b>1/8</b>	<b>0.125000</b>	<b>3.175</b>	<b>28.575</b>	<b>53.975</b>	<b>79.375</b>	<b>104.775</b>	<b>130.175</b>	<b>155.575</b>
9/64	0.140625	3.572	28.972	54.372	79.772	105.172	130.572	155.972
5/32	0.156250	3.969	29.369	54.769	80.169	105.569	130.969	156.369
11/64	0.171875	4.366	29.766	55.166	80.566	105.966	131.366	156.766
<b>3/16</b>	<b>0.187500</b>	<b>4.762</b>	<b>30.162</b>	<b>55.562</b>	<b>80.962</b>	<b>106.362</b>	<b>131.762</b>	<b>157.162</b>
13/64	0.203125	5.159	30.559	55.959	81.359	106.759	132.159	157.559
7/32	0.218750	5.556	30.956	56.356	81.756	107.156	132.556	157.956
15/64	0.234375	5.953	31.353	56.753	82.153	107.553	132.953	158.353
<b>1/4</b>	<b>0.250000</b>	<b>6.350</b>	<b>31.750</b>	<b>57.150</b>	<b>82.550</b>	<b>107.950</b>	<b>133.350</b>	<b>158.750</b>
17/64	0.265625	6.747	32.147	57.547	82.947	108.347	133.747	159.147
9/32	0.281250	7.144	32.544	57.944	83.344	108.744	134.144	159.544
19/64	0.296875	7.541	32.941	58.341	83.741	109.141	134.541	159.941
<b>5/16</b>	<b>0.312500</b>	<b>7.938</b>	<b>33.338</b>	<b>58.738</b>	<b>84.138</b>	<b>109.538</b>	<b>134.938</b>	<b>160.338</b>
21/64	0.328125	8.334	33.734	59.134	84.534	109.934	135.334	160.734
11/32	0.343750	8.731	34.131	59.531	84.931	110.331	135.731	161.131
23/64	0.359375	9.128	34.528	59.928	85.328	110.728	136.128	161.528
<b>3/8</b>	<b>0.375000</b>	<b>9.525</b>	<b>34.925</b>	<b>60.325</b>	<b>85.725</b>	<b>111.125</b>	<b>136.525</b>	<b>161.925</b>
25/64	0.390625	9.922	35.322	60.722	86.122	111.522	136.922	162.322
13/32	0.406250	10.319	35.719	61.119	86.519	111.919	137.319	162.719
27/64	0.421875	10.716	36.116	61.516	86.916	112.316	137.716	163.116
<b>7/16</b>	<b>0.437500</b>	<b>11.112</b>	<b>36.512</b>	<b>61.912</b>	<b>87.312</b>	<b>112.712</b>	<b>138.112</b>	<b>163.512</b>
29/64	0.453125	11.509	36.909	62.309	87.709	113.109	138.509	163.909
15/32	0.468750	11.906	37.306	62.706	88.106	113.506	138.906	164.306
31/64	0.484375	12.303	37.703	63.103	88.503	113.903	139.303	164.703
<b>1/2</b>	<b>0.500000</b>	<b>12.700</b>	<b>38.100</b>	<b>63.500</b>	<b>88.900</b>	<b>114.300</b>	<b>139.700</b>	<b>165.100</b>
33/64	0.515625	13.097	38.497	63.897	89.297	114.697	140.097	165.497
17/32	0.531250	13.494	38.894	64.294	89.694	115.094	140.494	165.894
35/64	0.546875	13.891	39.291	64.691	90.091	115.491	140.891	166.291
<b>9/16</b>	<b>0.562500</b>	<b>14.288</b>	<b>39.688</b>	<b>65.088</b>	<b>90.488</b>	<b>115.888</b>	<b>141.288</b>	<b>166.688</b>
37/64	0.578125	14.684	40.084	65.484	90.884	116.284	141.684	167.084
19/32	0.593750	15.081	40.481	65.881	91.281	116.681	142.081	167.481
39/64	0.609375	15.478	40.878	66.278	91.678	117.078	142.478	167.878
<b>5/8</b>	<b>0.625000</b>	<b>15.875</b>	<b>41.275</b>	<b>66.675</b>	<b>92.075</b>	<b>117.475</b>	<b>142.875</b>	<b>168.275</b>
41/64	0.640625	16.272	41.672	67.072	92.472	117.872	143.272	168.672
21/32	0.656250	16.669	42.069	67.469	92.869	118.269	143.669	169.069
43/64	0.671875	17.066	42.466	67.866	93.266	118.666	144.066	169.466
<b>11/16</b>	<b>0.687500</b>	<b>17.462</b>	<b>42.862</b>	<b>68.262</b>	<b>93.662</b>	<b>119.062</b>	<b>144.462</b>	<b>169.862</b>
45/64	0.703125	17.859	43.259	68.659	94.059	119.459	144.859	170.259
23/32	0.718750	18.256	43.656	69.056	94.456	119.856	145.256	170.656
47/64	0.734375	18.653	44.053	69.453	94.853	120.253	145.653	171.053
<b>3/4</b>	<b>0.750000</b>	<b>19.050</b>	<b>44.450</b>	<b>69.850</b>	<b>95.250</b>	<b>120.650</b>	<b>146.050</b>	<b>171.450</b>
49/64	0.765625	19.447	44.847	70.247	95.647	121.047	146.447	171.847
25/32	0.781250	19.844	45.244	70.644	96.044	121.444	146.844	172.244
51/64	0.796875	20.241	45.641	71.041	96.441	121.841	147.241	172.641
<b>13/16</b>	<b>0.812500</b>	<b>20.638</b>	<b>46.038</b>	<b>71.438</b>	<b>96.838</b>	<b>122.238</b>	<b>147.638</b>	<b>173.038</b>
53/64	0.828125	21.034	46.434	71.834	97.234	122.634	148.034	173.434
27/32	0.843750	21.431	46.831	72.231	97.631	123.031	148.431	173.831
55/64	0.859375	21.828	47.228	72.628	98.028	123.428	148.828	174.228
<b>7/8</b>	<b>0.875000</b>	<b>22.225</b>	<b>47.625</b>	<b>73.025</b>	<b>98.425</b>	<b>123.825</b>	<b>149.225</b>	<b>174.625</b>
57/64	0.890625	22.622	48.022	73.422	98.822	124.222	149.622	175.022
29/32	0.906250	23.019	48.419	73.819	99.219	124.619	150.019	175.419
59/64	0.921875	23.416	48.816	74.216	99.616	125.016	150.416	175.816
<b>15/16</b>	<b>0.937500</b>	<b>23.812</b>	<b>49.212</b>	<b>74.612</b>	<b>100.012</b>	<b>125.412</b>	<b>150.812</b>	<b>176.212</b>
61/64	0.953125	24.209	49.609	75.009	100.409	125.809	151.209	176.609
31/32	0.968750	24.606	50.006	75.406	100.806	126.206	151.606	177.006
63/64	0.984375	25.003	50.403	75.803	101.203	126.603	152.003	177.403

Conversion Table

1" = 25.4mm

inch		7	8	9	10	11	12
Fraction	Decimal	mm					
<b>0</b>	<b>0.000000</b>	<b>177.800</b>	<b>203.200</b>	<b>228.600</b>	<b>254.000</b>	<b>279.400</b>	<b>304.800</b>
1/64	0.015625	178.197	203.597	228.997	254.397	279.797	305.197
1/32	0.031250	178.594	203.994	229.394	254.794	280.194	305.594
3/64	0.046875	178.991	204.391	229.791	255.191	280.591	305.991
<b>1/16</b>	<b>0.062500</b>	<b>179.388</b>	<b>204.788</b>	<b>230.188</b>	<b>255.588</b>	<b>280.988</b>	<b>306.388</b>
5/64	0.078125	179.784	205.184	230.584	255.984	281.384	306.784
3/32	0.093750	180.181	205.581	230.981	256.381	281.781	307.181
7/64	0.109375	180.578	205.978	231.378	256.778	282.178	307.578
<b>1/8</b>	<b>0.125000</b>	<b>180.975</b>	<b>206.375</b>	<b>231.775</b>	<b>257.175</b>	<b>282.575</b>	<b>307.975</b>
9/64	0.140625	181.372	206.772	232.172	257.572	282.972	308.372
5/32	0.156250	181.769	207.169	232.569	257.969	283.369	308.769
11/64	0.171875	182.166	207.566	232.966	258.366	283.766	309.166
<b>3/16</b>	<b>0.187500</b>	<b>182.562</b>	<b>207.962</b>	<b>233.362</b>	<b>258.762</b>	<b>284.162</b>	<b>309.562</b>
13/64	0.203125	182.959	208.359	233.759	259.159	284.559	309.959
7/32	0.218750	183.356	208.756	234.156	259.556	284.956	310.356
15/64	0.234375	183.753	209.153	234.553	259.953	285.353	310.753
<b>1/4</b>	<b>0.250000</b>	<b>184.150</b>	<b>209.550</b>	<b>234.950</b>	<b>260.350</b>	<b>285.750</b>	<b>311.150</b>
17/64	0.265625	184.547	209.947	235.347	260.747	286.147	311.547
9/32	0.281250	184.944	210.344	235.744	261.144	286.544	311.944
19/64	0.296875	185.341	210.741	236.141	261.541	286.941	312.341
<b>5/16</b>	<b>0.312500</b>	<b>185.738</b>	<b>211.138</b>	<b>236.538</b>	<b>261.938</b>	<b>287.338</b>	<b>312.738</b>
21/64	0.328125	186.134	211.534	236.934	262.334	287.734	313.134
11/32	0.343750	186.531	211.931	237.331	262.731	288.131	313.531
23/64	0.359375	186.928	212.328	237.728	263.128	288.528	313.928
<b>3/8</b>	<b>0.375000</b>	<b>187.325</b>	<b>212.725</b>	<b>238.125</b>	<b>263.525</b>	<b>288.925</b>	<b>314.325</b>
25/64	0.390625	187.722	213.122	238.522	263.922	289.322	314.722
13/32	0.406250	188.119	213.519	238.919	264.319	289.719	315.119
27/64	0.421875	188.516	213.916	239.316	264.716	290.116	315.516
<b>7/16</b>	<b>0.437500</b>	<b>188.912</b>	<b>214.312</b>	<b>239.712</b>	<b>265.112</b>	<b>290.512</b>	<b>315.912</b>
29/64	0.453125	189.309	214.709	240.109	265.509	290.909	316.309
15/32	0.468750	189.706	215.106	240.506	265.906	291.306	316.706
31/64	0.484375	190.103	215.503	240.903	266.303	291.703	317.103



Appendix 7 Hardness Conversion Table (Reference)

Rockwell C Scale Hardness (1 471N {150kgf})	Vickers Hardness	Brinell Hardness		Rockwell Hardness		Shore Hardness
		Standard Ball	Tungsten Carbide Ball	A Scale	B Scale	
				Load 588.4N {60kgf} Brale Indenter	Load 980.7N {100kgf} 1.588mm Ball {1/16in}	
68	940	—	—	85.6	—	97
67	900	—	—	85.0	—	95
66	865	—	—	84.5	—	92
65	832	—	739	83.9	—	91
64	800	—	722	83.4	—	88
63	772	—	705	82.8	—	87
62	746	—	688	82.3	—	85
61	720	—	670	81.8	—	83
60	697	—	654	81.2	—	81
59	674	—	634	80.7	—	80
58	653	—	615	80.1	—	78
57	633	—	595	79.6	—	76
56	613	—	577	79.0	—	75
55	595	—	560	78.5	—	74
54	577	—	543	78.0	—	72
53	560	—	525	77.4	—	71
52	544	500	512	76.8	—	69
51	528	487	496	76.3	—	68
50	513	475	481	75.9	—	67
49	498	464	469	75.2	—	66
48	484	451	455	74.7	—	64
47	471	442	443	74.1	—	63
46	458	432	432	73.6	—	62
45	446	421	421	73.1	—	60
44	434	409	409	72.5	—	58
43	423	400	400	72.0	—	57
42	412	390	390	71.5	—	56
41	402	381	381	70.9	—	55
40	392	371	371	70.4	—	54
39	382	362	362	69.9	—	52
38	372	353	353	69.4	—	51
37	363	344	344	68.9	—	50
36	354	336	336	68.4	{109.0}	49
35	345	327	327	67.9	{108.5}	48
34	336	319	319	67.4	{108.0}	47
33	327	311	311	66.8	{107.5}	46
32	318	301	301	66.3	{107.0}	44
31	310	294	294	65.8	{106.0}	43
30	302	286	286	65.3	{105.5}	42
29	294	279	279	64.7	{104.5}	41
28	286	271	271	64.3	{104.0}	41
27	279	264	264	63.8	{103.0}	40
26	272	258	258	63.3	{102.5}	38
25	266	253	253	62.8	{101.5}	38
24	260	247	247	62.4	{101.0}	37
23	254	243	243	62.0	100.0	36
22	248	237	237	61.5	99.0	35
21	243	231	231	61.0	98.5	35
20	238	226	226	60.5	97.8	34
(18)	230	219	219	—	96.7	33
(16)	222	212	212	—	95.5	32
(14)	213	203	203	—	93.9	31
(12)	204	194	194	—	92.3	29
(10)	196	187	187	—	90.7	28
(8)	188	179	179	—	89.5	27
(6)	180	171	171	—	87.1	26
(4)	173	165	165	—	85.5	25
(2)	166	158	158	—	83.5	24
(0)	160	152	152	—	81.7	24

Appendix 8 Physical and Mechanical Properties of Materials

Materials	Specific Gravity	Coefficient of Linear Expansion (0° to 100°C)	Hardness (Brinell)	Modulus of Linear Elasticity (MPa) {kgf/mm <sup>2</sup> }	Tensile Strength (MPa) {kgf/mm <sup>2</sup> }	Yield Point (MPa) {kgf/mm <sup>2</sup> }	Elongation (%)
Bearing Steel (hardened)	7.83	12.5 × 10 <sup>-6</sup>	650 to 740	208 000 {21 200}	1 570 to 1 960 {160 to 200}	—	—
Martensitic Stainless Steel SUS 440C	7.68	10.1 × 10 <sup>-6</sup>	580	200 000 {20 400}	1 960 {200}	1 860 {190}	—
Mild Steel (C=0.12 to 0.20%)	7.86	11.6 × 10 <sup>-6</sup>	100 to 130	206 000 {21 000}	373 to 471 {38 to 48}	216 to 294 {22 to 30}	24 to 36
Hard Steel (C=0.3 to 0.5%)	7.84	11.3 × 10 <sup>-6</sup>	160 to 200	206 000 {21 000}	539 to 686 {55 to 70}	333 to 451 {34 to 46}	14 to 26
Austenitic Stainless Steel SUS 304	8.03	16.3 × 10 <sup>-6</sup>	150	193 000 {19 700}	588 {60}	245 {25}	60
Cast Iron	7.3	10.4 × 10 <sup>-6</sup>	Less than 223	98 100 {10 000}	More than 200 {20}	—	—
					Spheroidal graphite Iron FCD400	7.0	11.7 × 10 <sup>-6</sup>
Aluminum	2.69	23.7 × 10 <sup>-6</sup>	15 to 26	70 600 {7 200}	78 {8}	34 {3.5}	35
Zinc	7.14	31 × 10 <sup>-6</sup>	30 to 60	92 200 {9 400}	147 {15}	—	30 to 40
Copper	8.93	16.2 × 10 <sup>-6</sup>	50	123 000 {12 500}	196 {20}	69 {7}	15 to 20
Brass	8.5	19.1 × 10 <sup>-6</sup>	45	103 000 {10 500}	294 to 343 {30 to 35}	—	65 to 75
			85 to 130		363 to 539 {37 to 55}	—	15 to 50

**Remarks** The hardness of hardened bearing steel and martensitic stainless steel is usually expressed using the Rockwell C Scale, but for comparison, it is converted into Brinell hardness.

Appendix 9 Tolerances

Diameter Classification (mm)		Single Plane Mean Bore Deviation (Normal) $\Delta dmp$	a	c	d	e	f		g		h					
over	incl		a13	c12	d6	e6	f5	f6	g5	g6	h5	h6	h7	h8	h9	h10
3	6	0 - 8	-270 -450	- 70 -190	- 30 - 38	- 20 - 28	-10 -15	- 10 - 18	- 4 - 9	- 4 -12	- 0 - 5	- 0 - 8	- 0 -12	- 0 -18	- 0 - 30	- 0 - 48
6	10	0 - 8	-280 -500	- 80 -230	- 40 - 49	- 25 - 34	-13 -19	- 13 - 22	- 5 -11	- 5 -14	- 0 - 6	- 0 - 9	- 0 -15	- 0 -22	- 0 - 36	- 0 - 58
10	14	0 - 8	-290 -560	- 95 -275	- 50 - 61	- 32 - 43	-16 -24	- 16 - 27	- 6 -14	- 6 -17	- 0 - 8	- 0 -11	- 0 -18	- 0 -27	- 0 - 43	- 0 - 70
14	18															
18	24	0 -10	-300 -630	-110 -320	- 65 - 78	- 40 - 53	-20 -29	- 20 - 33	- 7 -16	- 7 -20	- 0 - 9	- 0 -13	- 0 -21	- 0 -33	- 0 - 52	- 0 - 84
24	30															
30	40	0 -12	- 310 - 700	- 120 - 370	- 80 - 96	- 50 - 66	-25 -36	- 25 - 41	- 9 -20	- 9 -25	- 0 -11	- 0 -16	- 0 -25	- 0 -39	- 0 - 62	- 0 -100
40	50															
50	65	0 -15	- 340 - 800	- 140 - 440	-100 -119	- 60 - 79	-30 -43	- 30 - 49	-10 -23	-10 -29	- 0 -13	- 0 -19	- 0 -30	- 0 -46	- 0 - 74	- 0 -120
65	80															
80	100	0 -20	- 380 - 920	- 170 - 520	-120 -142	- 72 - 94	-36 -51	- 36 - 58	-12 -27	-12 -34	- 0 -15	- 0 -22	- 0 -35	- 0 -54	- 0 - 87	- 0 -140
100	120															
120	140	0 -25	- 460 -1 090	- 200 - 600	-145 -170	- 85 -110	-43 -61	- 43 - 68	-14 -32	-14 -39	- 0 -18	- 0 -25	- 0 -40	- 0 -63	- 0 -100	- 0 -160
140	160															
160	180															
180	200	0 -30	- 660 -1 380	- 240 - 700	-170 -199	-100 -129	-50 -70	- 50 - 79	-15 -35	-15 -44	- 0 -20	- 0 -29	- 0 -46	- 0 -72	- 0 -115	- 0 -185
200	225															
225	250															
250	280	0 -35	- 920 -1 730	- 300 - 820	-190 -222	-110 -142	-56 -79	- 56 - 88	-17 -40	-17 -49	- 0 -23	- 0 -32	- 0 -52	- 0 -81	- 0 -130	- 0 -210
280	315															
315	355	0 -40	-1 200 -2 090	- 360 - 930	-210 -246	-125 -161	-62 -87	- 62 - 98	-18 -43	-18 -54	- 0 -25	- 0 -36	- 0 -57	- 0 -89	- 0 -140	- 0 -230
355	400															
400	450	0 -45	-1 500 -2 470	- 440 -1 070	-230 -270	-135 -175	-68 -95	- 68 -108	-20 -47	-20 -60	- 0 -27	- 0 -40	- 0 -63	- 0 -97	- 0 -155	- 0 -250
450	500															

for Shaft Diameters

Units:  $\mu\text{m}$

Diameter Classification (mm)		js		j		k		m		n		p		r		over	incl
over	incl	js5	js6	j5	j6	k5	k6	m5	m6	n5	n6	p5	p6	r6	r7		
3	6	$\pm 2.5$	$\pm 4$	$+ 3$ - 2	$+ 6$ - 2	$+ 6$ + 1	$+ 9$ + 1	$+ 9$ + 4	$+ 12$ + 4	$+ 13$ + 8	$+ 16$ + 8	$+ 17$ + 12	$+ 20$ + 12	$+ 23$ + 15	$+ 27$ + 15	3	6
6	10	$\pm 3$	$\pm 4.5$	$+ 4$ - 2	$+ 7$ - 2	$+ 7$ + 1	$+ 10$ + 1	$+ 12$ + 6	$+ 15$ + 6	$+ 16$ + 10	$+ 19$ + 10	$+ 21$ + 15	$+ 24$ + 15	$+ 28$ + 19	$+ 34$ + 19	6	10
10	14	$\pm 4$	$\pm 5.5$	$+ 5$ - 3	$+ 8$ - 3	$+ 9$ + 1	$+ 12$ + 1	$+ 15$ + 7	$+ 18$ + 7	$+ 20$ + 12	$+ 23$ + 12	$+ 26$ + 18	$+ 29$ + 18	$+ 34$ + 23	$+ 41$ + 23	10	14
14	18															14	18
18	24	$\pm 4.5$	$\pm 6.5$	$+ 5$ - 4	$+ 9$ - 4	$+ 11$ + 2	$+ 15$ + 2	$+ 17$ + 8	$+ 21$ + 8	$+ 24$ + 15	$+ 28$ + 15	$+ 31$ + 22	$+ 35$ + 22	$+ 41$ + 28	$+ 49$ + 28	18	24
24	30															24	30
30	40	$\pm 5.5$	$\pm 8$	$+ 6$ - 5	$+ 11$ - 5	$+ 13$ + 2	$+ 18$ + 2	$+ 20$ + 9	$+ 25$ + 9	$+ 28$ + 17	$+ 33$ + 17	$+ 37$ + 26	$+ 42$ + 26	$+ 50$ + 34	$+ 59$ + 34	30	40
40	50															40	50
50	65	$\pm 6.5$	$\pm 9.5$	$+ 6$ - 7	$+ 12$ - 7	$+ 15$ + 2	$+ 21$ + 2	$+ 24$ + 11	$+ 30$ + 11	$+ 33$ + 20	$+ 39$ + 20	$+ 45$ + 32	$+ 51$ + 32	$+ 60$ + 41	$+ 71$ + 41	50	65
65	80													$+ 62$ + 43	$+ 73$ + 43	65	80
80	100	$\pm 7.5$	$\pm 11$	$+ 6$ - 9	$+ 13$ - 9	$+ 18$ + 3	$+ 25$ + 3	$+ 28$ + 13	$+ 35$ + 13	$+ 38$ + 23	$+ 45$ + 23	$+ 52$ + 37	$+ 59$ + 37	$+ 73$ + 51	$+ 86$ + 51	80	100
100	120													$+ 76$ + 54	$+ 89$ + 54	100	120
120	140	$\pm 9$	$\pm 12.5$	$+ 7$ - 11	$+ 14$ - 11	$+ 21$ + 3	$+ 28$ + 3	$+ 33$ + 15	$+ 40$ + 15	$+ 45$ + 27	$+ 52$ + 27	$+ 61$ + 43	$+ 68$ + 43	$+ 88$ + 63	$+ 103$ + 63	120	140
140	160													$+ 90$ + 65	$+ 105$ + 65	140	160
160	180													$+ 93$ + 68	$+ 108$ + 68	160	180
180	200	$\pm 10$	$\pm 14.5$	$+ 7$ - 13	$+ 16$ - 13	$+ 24$ + 4	$+ 33$ + 4	$+ 37$ + 17	$+ 46$ + 17	$+ 51$ + 31	$+ 60$ + 31	$+ 70$ + 50	$+ 79$ + 50	$+ 106$ + 77	$+ 123$ + 77	180	200
200	225													$+ 109$ + 80	$+ 126$ + 80	200	225
225	250													$+ 113$ + 84	$+ 130$ + 84	225	250
250	280	$\pm 11.5$	$\pm 16$	$+ 7$ - 16	$\pm 16$	$+ 27$ + 4	$+ 36$ + 4	$+ 43$ + 20	$+ 52$ + 20	$+ 57$ + 34	$+ 66$ + 34	$+ 79$ + 56	$+ 88$ + 56	$+ 126$ + 94	$+ 146$ + 94	250	280
280	315													$+ 130$ + 98	$+ 150$ + 98	280	315
315	355	$\pm 12.5$	$\pm 18$	$+ 7$ - 18	$\pm 18$	$+ 29$ + 4	$+ 40$ + 4	$+ 46$ + 21	$+ 57$ + 21	$+ 62$ + 37	$+ 73$ + 37	$+ 87$ + 62	$+ 98$ + 62	$+ 144$ + 108	$+ 165$ + 108	315	355
355	400													$+ 150$ + 114	$+ 171$ + 114	355	400
400	450	$\pm 13.5$	$\pm 20$	$+ 7$ - 20	$\pm 20$	$+ 32$ + 5	$+ 45$ + 5	$+ 50$ + 23	$+ 63$ + 23	$+ 67$ + 40	$+ 80$ + 40	$+ 95$ + 68	$+ 108$ + 68	$+ 166$ + 126	$+ 189$ + 126	400	450
450	500													$+ 172$ + 132	$+ 195$ + 132	450	500



## Appendix 11 Values of Standard

Basic Size (mm)		Standard										
		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11
over	incl	Tolerances (μm)										
—	3	0.8	1.2	2	3	4	6	10	14	25	40	60
3	6	1	1.5	2.5	4	5	8	12	18	30	48	75
6	10	1	1.5	2.5	4	6	9	15	22	36	58	90
10	18	1.2	2	3	5	8	11	18	27	43	70	110
18	30	1.5	2.5	4	6	9	13	21	33	52	84	130
30	50	1.5	2.5	4	7	11	16	25	39	62	100	160
50	80	2	3	5	8	13	19	30	46	74	120	190
80	120	2.5	4	6	10	15	22	35	54	87	140	220
120	180	3.5	5	8	12	18	25	40	63	100	160	250
180	250	4.5	7	10	14	20	29	46	72	115	185	290
250	315	6	8	12	16	23	32	52	81	130	210	320
315	400	7	9	13	18	25	36	57	89	140	230	360
400	500	8	10	15	20	27	40	63	97	155	250	400
500	630	9	11	16	22	32	44	70	110	175	280	440
630	800	10	13	18	25	36	50	80	125	200	320	500
800	1 000	11	15	21	28	40	56	90	140	230	360	560
1 000	1 250	13	18	24	33	47	66	105	165	260	420	660
1 250	1 600	15	21	29	39	55	78	125	195	310	500	780
1 600	2 000	18	25	35	46	65	92	150	230	370	600	920
2 000	2 500	22	30	41	55	78	110	175	280	440	700	1 100
2 500	3 150	26	36	50	68	96	135	210	330	540	860	1 350

**Remarks** 1. Standard tolerance grades IT14 to IT18 shall not be used for basic sizes less than or equal to 1 mm.  
2. Values for standard tolerance grades IT1 to IT5 for basic sizes over 500 mm are included for experimental use.

## Tolerance Grades IT

Grades							Basic Size (mm)	
IT12	IT13	IT14	IT15	IT16	IT17	IT18		
Tolerances (mm)							over	incl
0.10	0.14	0.25	0.40	0.60	1.00	1.40	—	3
0.12	0.18	0.30	0.48	0.75	1.20	1.80	3	6
0.15	0.22	0.36	0.58	0.90	1.50	2.20	6	10
0.18	0.27	0.43	0.70	1.10	1.80	2.70	10	18
0.21	0.33	0.52	0.84	1.30	2.10	3.30	18	30
0.25	0.39	0.62	1.00	1.60	2.50	3.90	30	50
0.30	0.46	0.74	1.20	1.90	3.00	4.60	50	80
0.35	0.54	0.87	1.40	2.20	3.50	5.40	80	120
0.40	0.63	1.00	1.60	2.50	4.00	6.30	120	180
0.46	0.72	1.15	1.85	2.90	4.60	7.20	180	250
0.52	0.81	1.30	2.10	3.20	5.20	8.10	250	315
0.57	0.89	1.40	2.30	3.60	5.70	8.90	315	400
0.63	0.97	1.55	2.50	4.00	6.30	9.70	400	500
0.70	1.10	1.75	2.80	4.40	7.00	11.00	500	630
0.80	1.25	2.00	3.20	5.00	8.00	12.50	630	800
0.90	1.40	2.30	3.60	5.60	9.00	14.00	800	1 000
1.05	1.65	2.60	4.20	6.60	10.50	16.50	1 000	1 250
1.25	1.95	3.10	5.00	7.80	12.50	19.50	1 250	1 600
1.50	2.30	3.70	6.00	9.20	15.00	23.00	1 600	2 000
1.75	2.80	4.40	7.00	11.00	17.50	28.00	2 000	2 500
2.10	3.30	5.40	8.60	13.50	21.00	33.00	2 500	3 150

Appendix 12 Speed Factor  $f_n$

Ball Bearings  $f_n = (0.03n)^{-1/3}$   
 Roller Bearings  $f_n = (0.03n)^{-3/10}$

Speed $n$ (min <sup>-1</sup> )	Speed Factor $f_n$		Speed $n$ (min <sup>-1</sup> )	Speed Factor $f_n$		Speed $n$ (min <sup>-1</sup> )	Speed Factor $f_n$	
	Ball Bearings	Roller Bearings		Ball Bearings	Roller Bearings		Ball Bearings	Roller Bearings
10	1.49	1.44	180	0.570	0.603	3 000	0.259	
11	1.45	1.39	190	0.560	0.593	3 200	0.254	
12	1.41	1.36	200	0.550	0.584	3 400	0.250	
13	1.37	1.33	220	0.533	0.568	3 600	0.245	
14	1.34	1.30	240	0.518	0.553	3 800	0.242	
15	1.30	1.27	260	0.504	0.540	4 000	0.238	
16	1.28	1.25	280	0.492	0.528	4 200	0.234	
17	1.25	1.22	300	0.481	0.517	4 400	0.231	
18	1.23	1.20	320	0.471	0.507	4 600	0.228	
19	1.21	1.18	340	0.461	0.498	4 800	0.225	
20	1.19	1.17	360	0.452	0.490	5 000	0.222	
21	1.17	1.15	380	0.444	0.482	5 200	0.220	
22	1.15	1.13	400	0.437	0.475	5 400	0.217	
23	1.13	1.12	420	0.430	0.468	5 600	0.215	
24	1.12	1.10	440	0.423	0.461	5 800	0.213	
25	1.10	1.09	460	0.417	0.455	6 000	0.211	
26	1.09	1.08	480	0.411	0.449	6 200	0.209	
27	1.07	1.07	500	0.405	0.444	6 400	0.207	
28	1.06	1.05	550	0.393	0.431	6 600	0.205	
29	1.05	1.04	600	0.382	0.420	6 800	0.203	
30	1.04	1.03	650	0.372	0.410	7 000	0.201	
31	1.02	1.02	700	0.362	0.401	7 200	0.199	
32	1.01	1.01	750	0.354	0.393	7 400	0.198	
33.3	1.00	1.00	800	0.347	0.385	7 600	0.196	
34	0.993	0.994	850	0.340	0.378	7 800	0.195	
36	0.975	0.977	900	0.333	0.372	8 000	0.193	
38	0.957	0.961	950	0.327	0.366	8 500	0.190	
40	0.941	0.947	1 000	0.322	0.360	9 000	0.186	
42	0.926	0.933	1 050	0.317	0.355	9 500	0.183	
44	0.912	0.920	1 100	0.312	0.350	10 000	0.181	
46	0.898	0.908	1 150	0.307	0.346	11 000	0.176	
48	0.886	0.896	1 200	0.303	0.341	12 000	0.171	
50	0.874	0.885	1 250	0.299	0.337	13 000	0.167	
55	0.846	0.861	1 300	0.295	0.333	14 000	0.163	
60	0.822	0.838	1 400	0.288	0.326	15 000	0.160	
65	0.800	0.818	1 500	0.281	0.319	16 000	0.157	
70	0.781	0.800	1 600	0.275	0.313	17 000	0.154	
75	0.763	0.784	1 700	0.270	0.307	18 000	0.151	
80	0.747	0.769	1 800	0.265	0.302	19 000	0.149	
85	0.732	0.755	1 900	0.260	0.297	20 000	0.147	
90	0.718	0.742	2 000	0.255	0.293	22 000	0.143	
95	0.705	0.730	2 100	0.251	0.289	24 000	0.139	
100	0.693	0.719	2 200	0.247	0.285	26 000	0.136	
110	0.672	0.699	2 300	0.244	0.281	28 000	0.133	
120	0.652	0.681	2 400	0.240	0.277	30 000	0.130	
130	0.635	0.665	2 500	0.237	0.274	32 000	0.127	
140	0.620	0.650	2 600	0.234	0.271	34 000	0.125	
150	0.606	0.637	2 700	0.231	0.268	36 000	0.123	
160	0.593	0.625	2 800	0.228	0.265	38 000	0.121	
170	0.581	0.613	2 900	0.226	0.262	40 000	0.119	

Appendix 13 Fatigue Life Factor  $f_h$  and Fatigue Life  $L \cdot L_h$

Ball Bearings  $L = (C/P)^3$   $L_h = 500f_h^3$   
 Roller Bearings  $L = (C/P)^{10/3}$   $L_h = 500f_h^{10/3}$

C/P or $f_h$	Ball Bearing Life		Roller Bearing Life		C/P or $f_h$	Ball Bearing Life		Roller Bearing Life	
	$L$ (10 <sup>6</sup> rev)	$L_h$ (h)	$L$ (10 <sup>6</sup> rev)	$L_h$ (h)		$L$ (10 <sup>6</sup> rev)	$L_h$ (h)	$L$ (10 <sup>6</sup> rev)	$L_h$ (h)
0.70	0.34	172	0.30	152	3.45	41.1	20 500	62.0	31 000
0.75	0.42	211	0.38	192	3.50	42.9	21 400	65.1	32 500
0.80	0.51	256	0.48	238	3.55	44.7	22 400	68.2	34 100
0.85	0.61	307	0.58	291	3.60	46.7	23 300	71.5	35 800
0.90	0.73	365	0.70	352	3.65	48.6	24 300	74.9	37 400
0.95	0.86	429	0.84	421	3.70	50.7	25 300	78.3	39 200
1.00	1.00	500	1.00	500	3.75	52.7	26 400	81.9	41 000
1.05	1.16	579	1.18	588	3.80	54.9	27 400	85.6	42 800
1.10	1.33	665	1.37	687	3.85	57.1	28 500	89.4	44 700
1.15	1.52	760	1.59	797	3.90	59.3	29 700	93.4	46 700
1.20	1.73	864	1.84	918	3.95	61.6	30 800	97.4	48 700
1.25	1.95	977	2.10	1 050	4.00	64.0	32 000	102	50 800
1.30	2.20	1 100	2.40	1 200	4.05	66.4	33 200	106	52 900
1.35	2.46	1 230	2.72	1 360	4.10	68.9	34 500	110	55 200
1.40	2.74	1 370	3.07	1 530	4.15	71.5	35 700	115	57 400
1.45	3.05	1 520	3.45	1 730	4.20	74.1	37 000	120	59 800
1.50	3.38	1 690	3.86	1 930	4.25	76.8	38 400	124	62 200
1.55	3.72	1 860	4.31	2 150	4.30	79.5	39 800	129	64 600
1.60	4.10	2 050	4.79	2 400	4.35	82.3	41 200	134	67 200
1.65	4.49	2 250	5.31	2 650	4.40	85.2	42 600	140	69 800
1.70	4.91	2 460	5.86	2 930	4.45	88.1	44 100	145	72 500
1.75	5.36	2 680	6.46	3 230	4.50	91.1	45 600	150	75 200
1.80	5.83	2 920	7.09	3 550	4.55	94.2	47 100	156	78 000
1.85	6.33	3 170	7.77	3 890	4.60	97.3	48 700	162	80 900
1.90	6.86	3 430	8.50	4 250	4.65	101	50 300	168	83 900
1.95	7.41	3 710	9.26	4 630	4.70	104	51 900	174	87 000
2.00	8.00	4 000	10.1	5 040	4.75	107	53 600	180	90 100
2.05	8.62	4 310	10.9	5 470	4.80	111	55 300	187	93 300
2.10	9.26	4 630	11.9	5 930	4.85	114	57 000	193	96 600
2.15	9.94	4 970	12.8	6 410	4.90	118	58 800	200	99 900
2.20	10.6	5 320	13.8	6 920	4.95	121	60 600	207	103 000
2.25	11.4	5 700	14.9	7 460	5.00	125	62 500	214	107 000
2.30	12.2	6 080	16.1	8 030	5.10	133	66 300	228	114 000
2.35	13.0	6 490	17.3	8 630	5.20	141	70 300	244	122 000
2.40	13.8	6 910	18.5	9 250	5.30	149	74 400	260	130 000
2.45	14.7	7 350	19.8	9 910	5.40	157	78 700	276	138 000
2.50	15.6	7 810	21.2	10 600	5.50	166	83 200	294	147 000
2.55	16.6	8 290	22.7	11 300	5.60	176	87 800	312	156 000
2.60	17.6	8 790	24.2	12 100	5.70	185	92 600	331	165 000
2.65	18.6	9 300	25.8	12 900	5.80	195	97 600	351	175 000
2.70	19.7	9 840	27.4	13 700	5.90	205	103 000	371	186 000
2.75	20.8	10 400	29.1	14 600	6.00	216	108 000	392	196 000
2.80	22.0	11 000	30.9	15 500	6.50	275	137 000	513	256 000
2.85	23.1	11 600	32.8	16 400	7.00	343	172 000	656	328 000
2.90	24.4	12 200	34.8	17 400	7.50	422	211 000	826	413 000
2.95	25.7	12 800	36.8	18 400	8.00	512	256 000	1 020	512 000
3.00	27.0	13 500	38.9	19 500	8.50	614	307 000	1 250	627 000
3.05	28.4	14 200	41.1	20 600	9.00	729	365 000	1 520	758 000
3.10	29.8	14 900	43.4	21 700	9.50	857	429 000	1 820	908 000
3.15	31.3	15 600	45.8	22 900	10.0	1 000	—	2 150	—
3.20	32.8	16 400	48.3	24 100	11.0	1 330	—	2 960	—
3.25	34.3	17 200	50.8	25 400	12.0	1 730	—	3 960	—
3.30	35.9	18 000	53.5	26 800	13.0	2 200	—	5 170	—
3.35	37.6	18 800	56.3	28 100	14.0	2 740	—	6 610	—
3.40	39.3	19 700	59.1	29 600	15.0	3 380	—	8 320	—







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